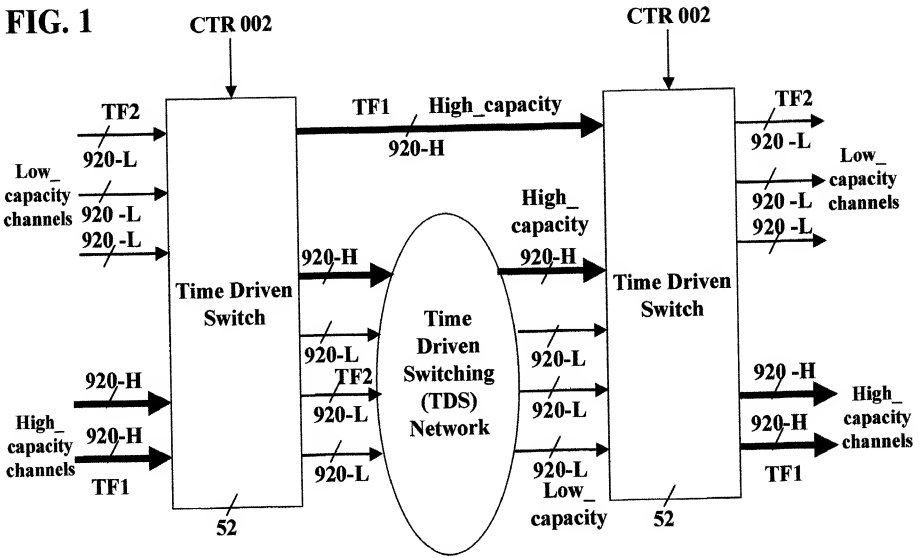
FIG. 1



c = High_capacity/Low_capacity

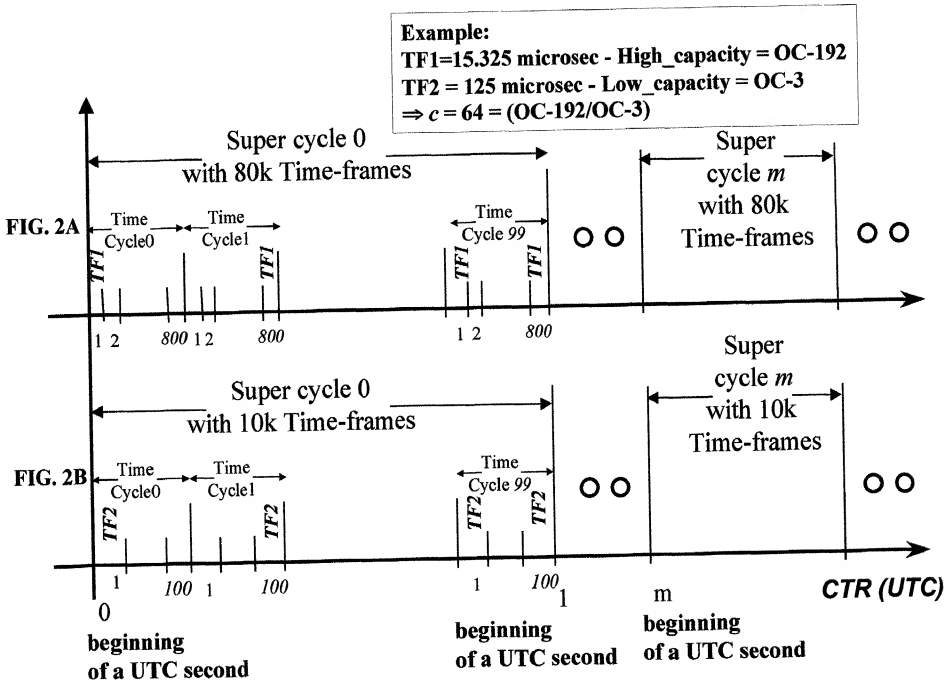


FIG. 3

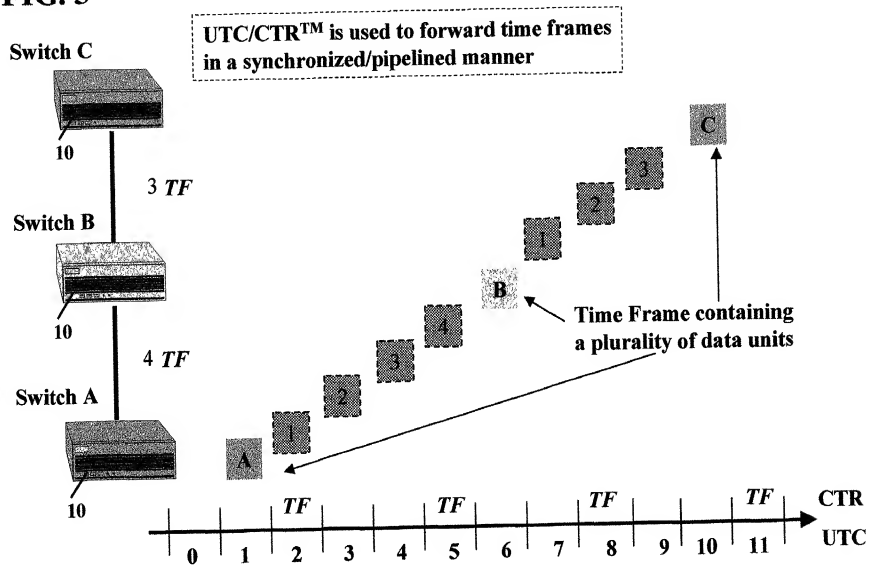


FIG. 4A

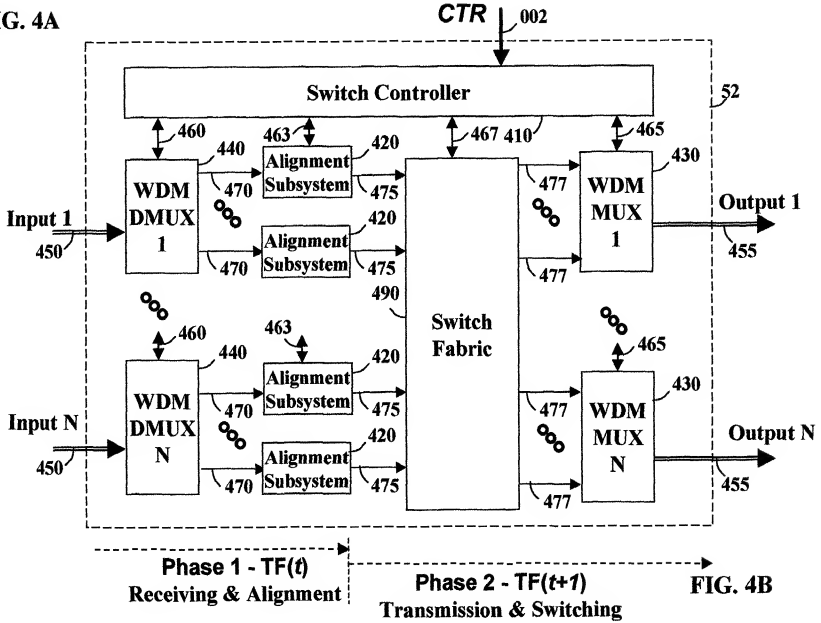


FIG. 4B

FIG. 5

Two time intervals: SC1_length·TF1 = 1 UTC second

- SC2_length·TF2 = 1 UTC second
- TF2 = (SC1_length / SC2_length) · TF1 = k · TF1, where the time cycles of TF1 and TF2 are aligned with respect to UTC.

For $k = 2$ and $c = 4$ (e.g., High_capacity=OC-192, Low_capacity=OC-48):

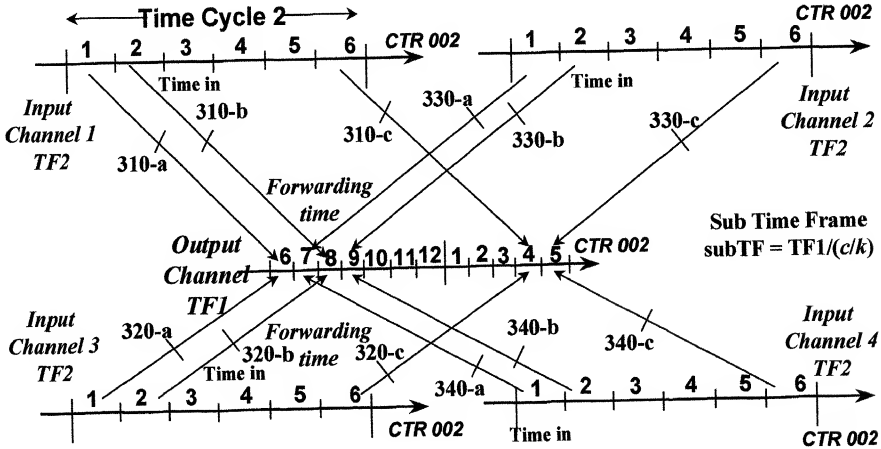


FIG. 6

Two time intervals: ***SC1_length·TF1 = 1*** **UTC second**

- ***SC2_length·TF2 = 1*** **UTC second**
- ***TF2 = (SC1_length / SC2_length) · TF1 = k · TF1***, where the time cycles of ***TF1*** and ***TF2*** are aligned with respect to UTC.

For $k = 2$ and $c = 4$ (e.g., High_capacity=OC-192, Low_capacity=OC-48):

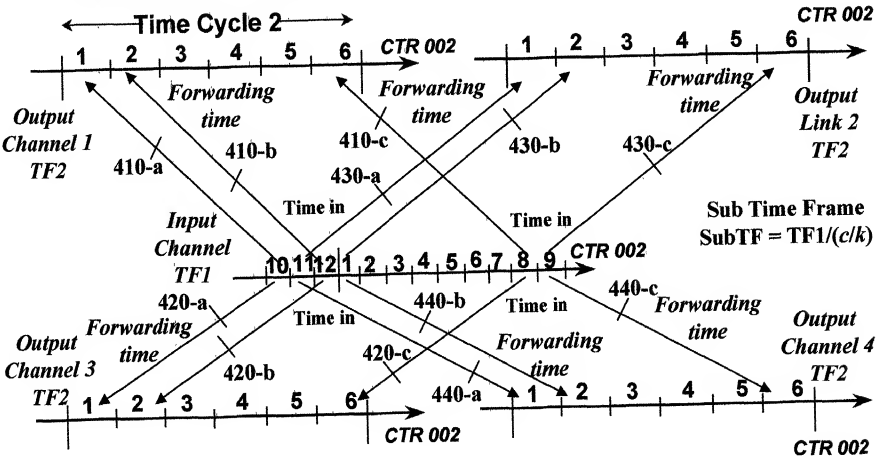


FIG. 7

Two time intervals: *SC1_length·TF1 = 1* UTC second

- *SC2_length·TF2 = 1* UTC second
- *TF2 = (SC1_length / SC2_length) · TF1 = k · TF1*, where the time cycles of *TF1* and *TF2* are aligned with respect to UTC.
  For *k* = 2 and *c* = 4 (e.g., High_capacity=OC-192, Low_capacity=OC-48):

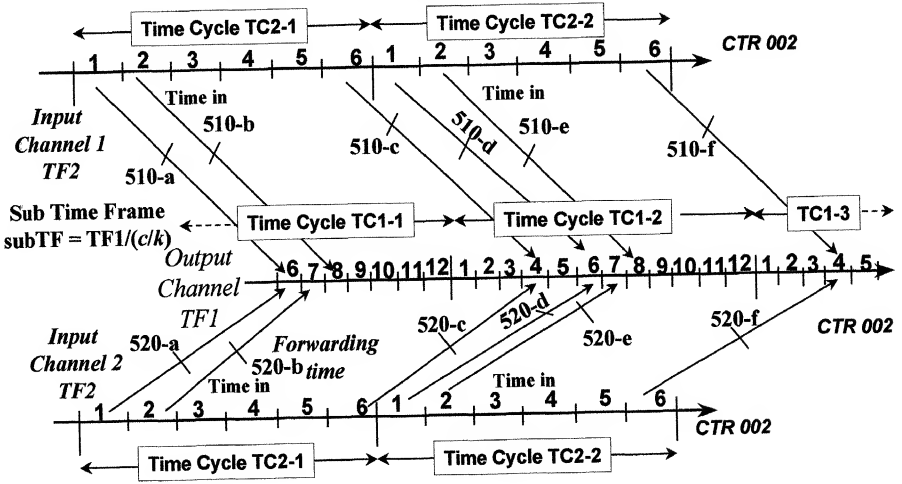


FIG. 8

Two time intervals: $SC1\_length \cdot TF1 = 1$ UTC second

- $SC2\_length \cdot TF2 = 1$ UTC second
- $TF2 = (SC1\_length / SC2\_length) \cdot TF1 = k \cdot TF1$, where the time cycles of $TF1$ and $TF2$ are aligned with respect to UTC.

For $k = 2$ and $c = 4$ (e.g., High_capacity=OC-192, Low_capacity=OC-48):

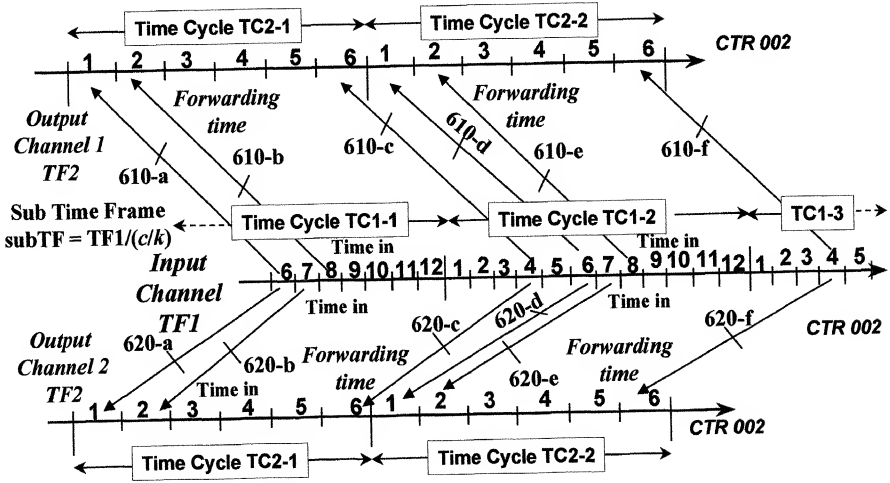


FIG. 9

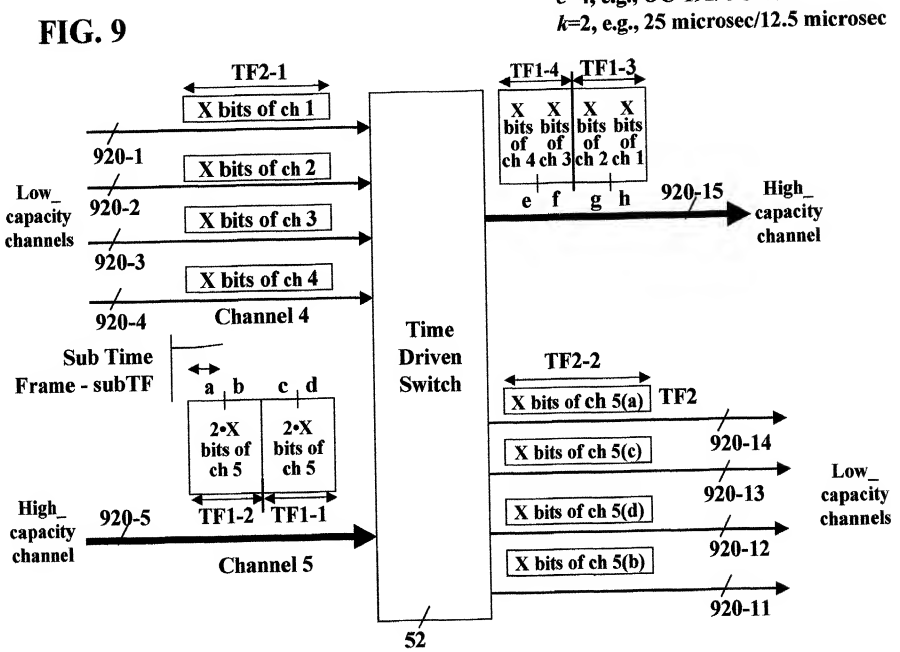


FIG. 10

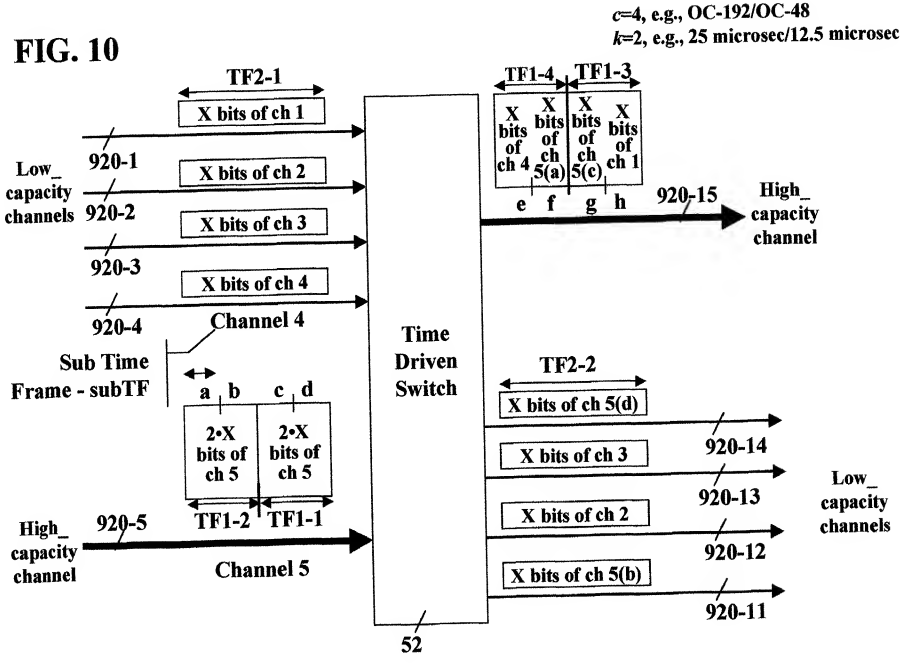


FIG. 11

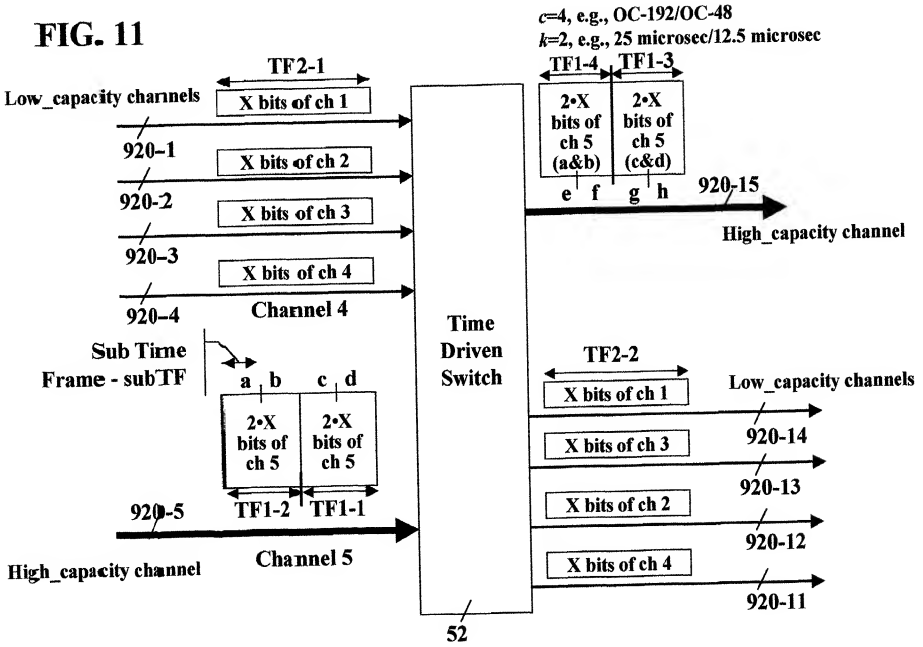


FIG. 12A

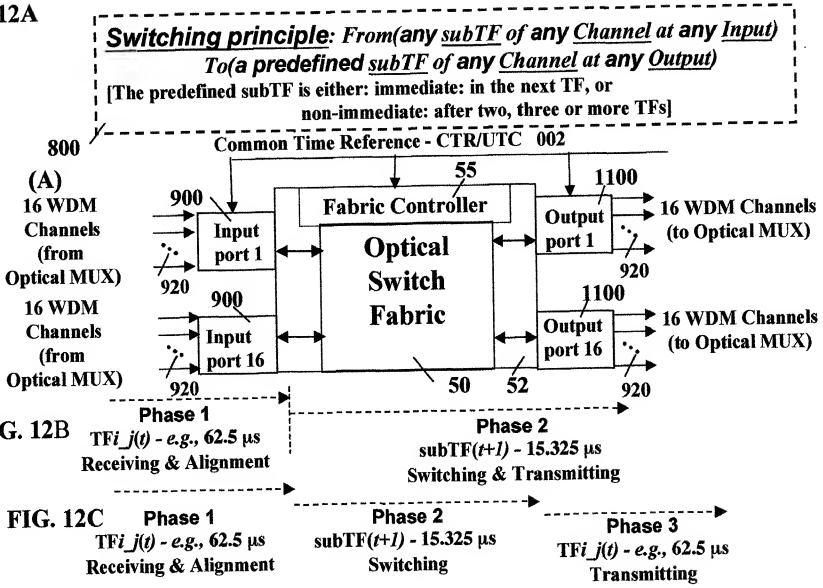


FIG. 12B

FIG. 12C

FIG. 13

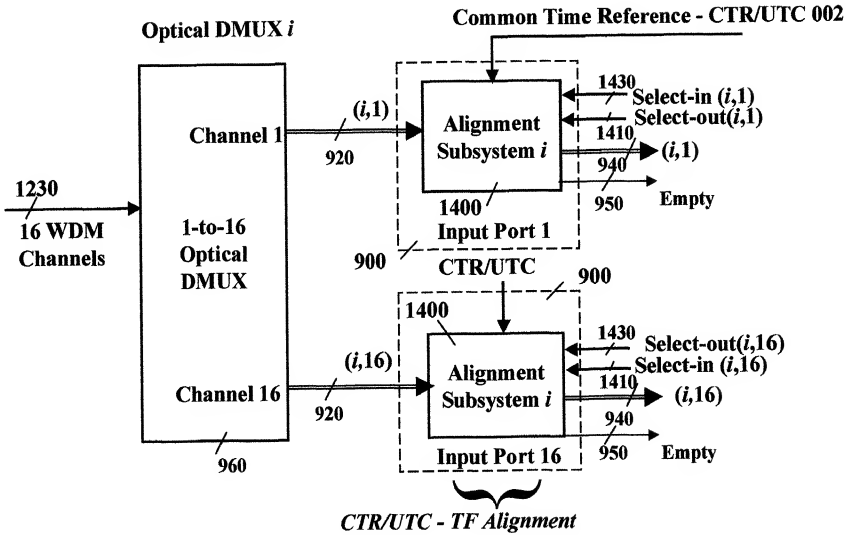


FIG. 14

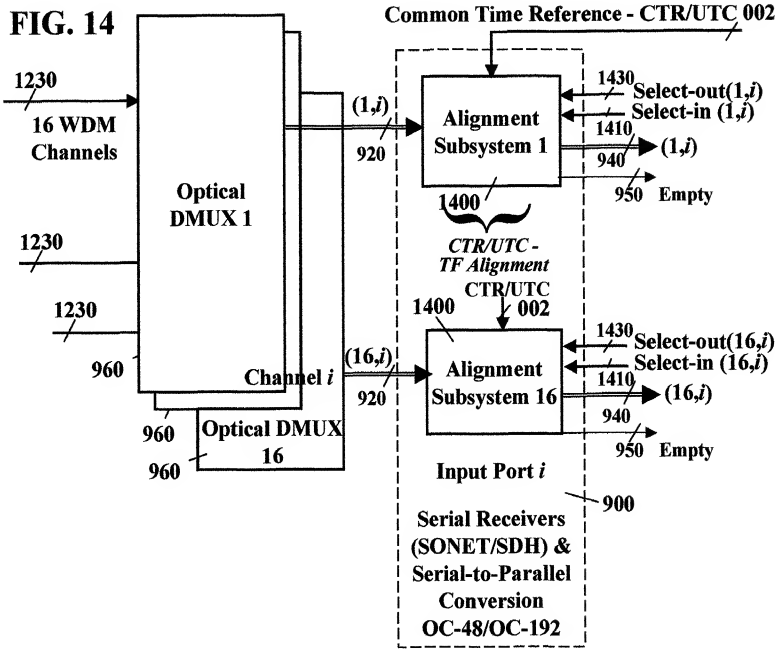


FIG. 15

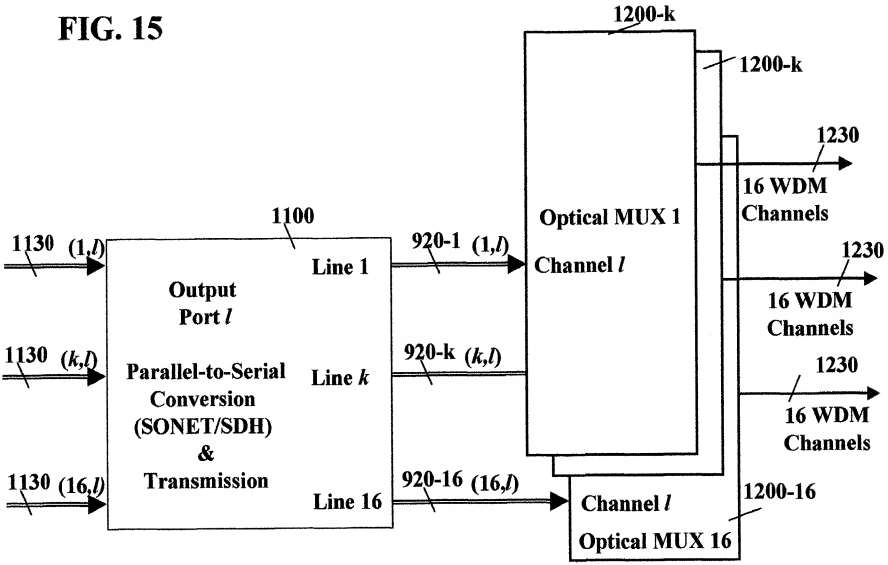


FIG. 16

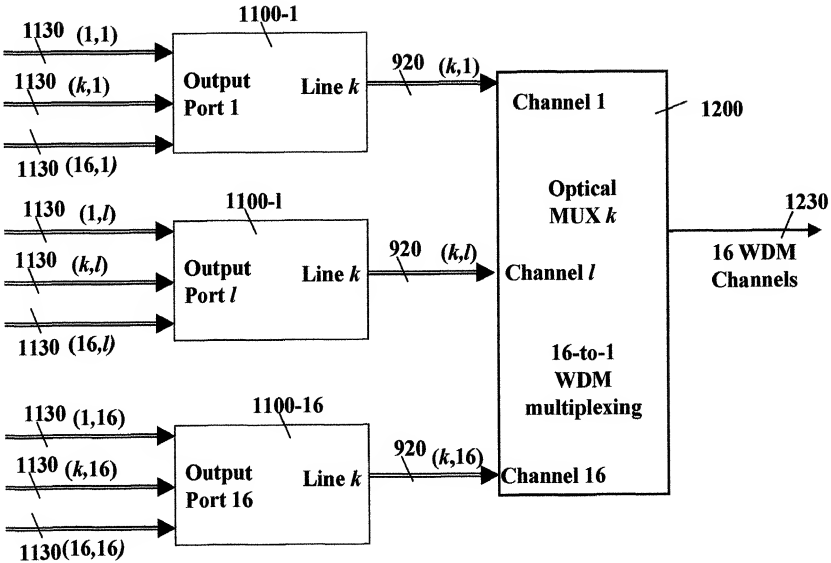


FIG. 17

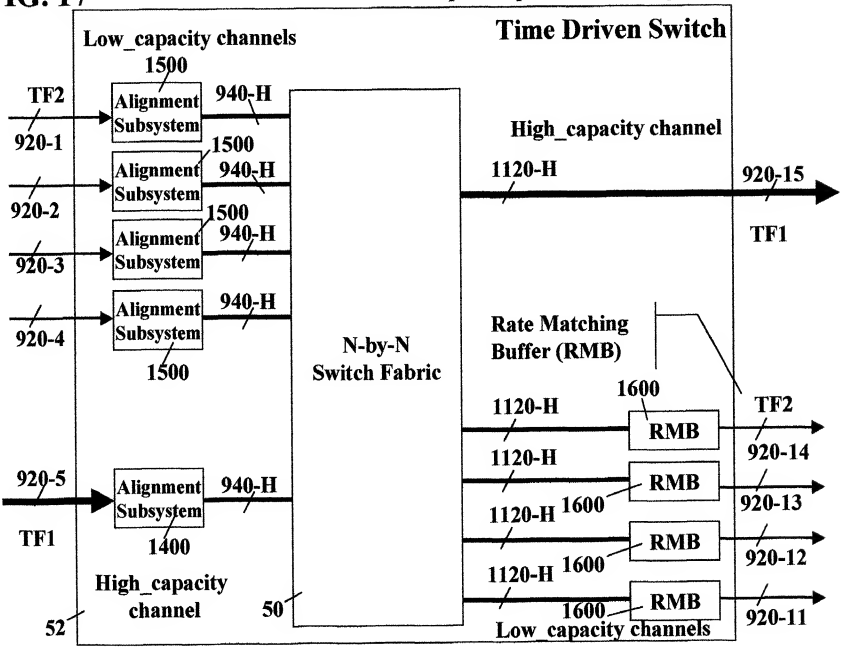
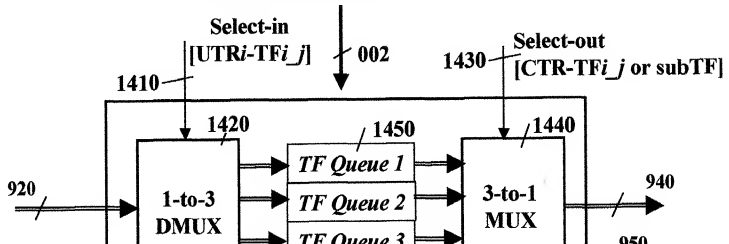


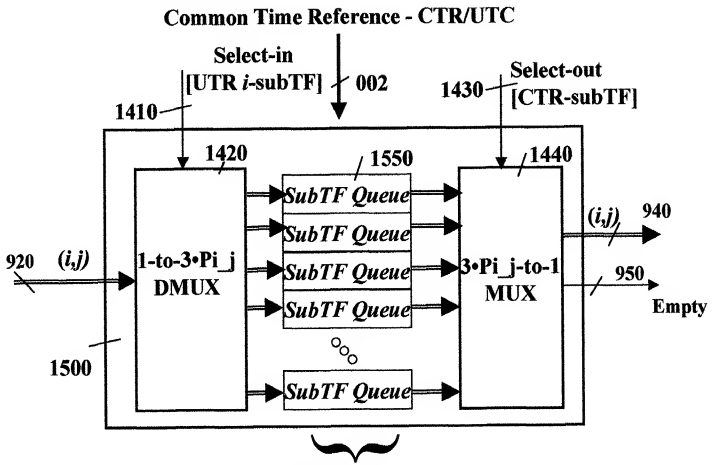
FIG. 18



Alignment Subsystem for Channel *j* at Input Interface *i*
with a Plurality of Time Frame Queues

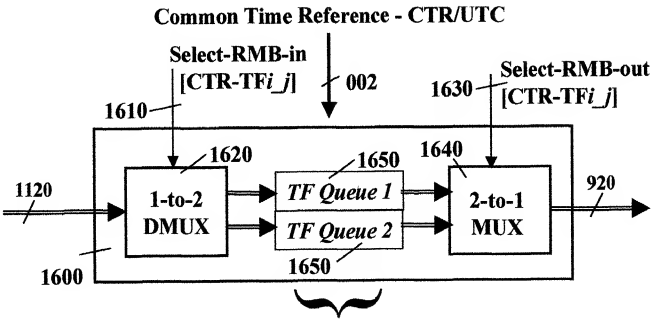
FIG. 19

TF*i_j*: Time frame duration on channel *j* at Input Interface *i*.
UTR *i*: UTR on link connected to Input Interface *i*
P*i_j* = TF*i_j*/subTF



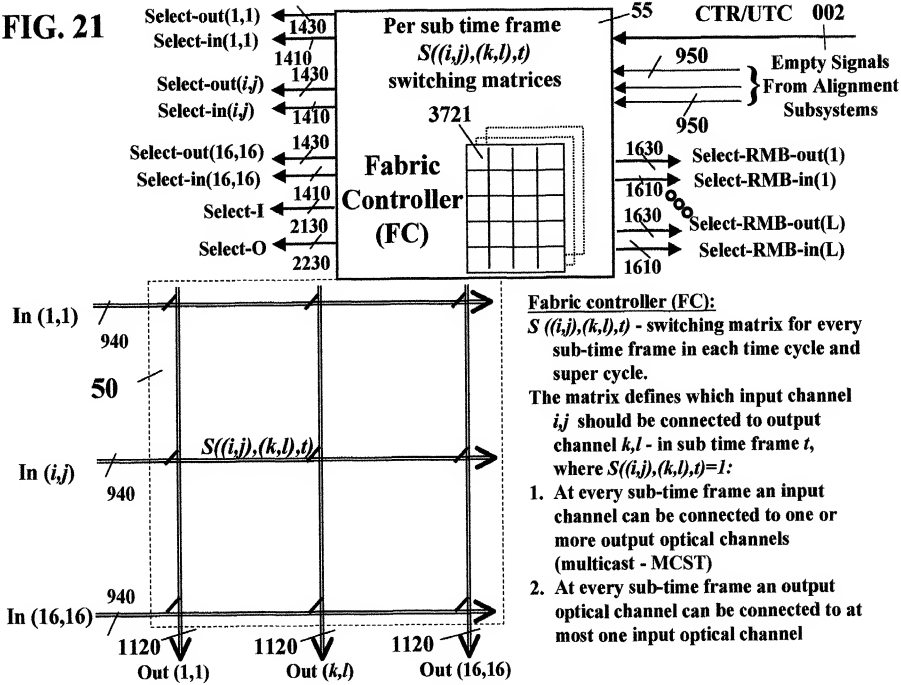
Alignment Subsystem for *high capacity* Channel *j* at Input Interface *i*
with a Plurality of Sub-Time Frame Queues

FIG. 20 **TF*i_j*: Time frame duration on channel *j* at Input Interface *i*.**
UTR*i*: UTR on link connected to Input Interface *i*



Rate Matching Buffer for Channel *j* at Output Interface *i*
with a Plurality of Time Frame Queues
(Also single buffer with dual access memory with single phase switching and forwarding)

FIG. 21



Fabric controller (FC):

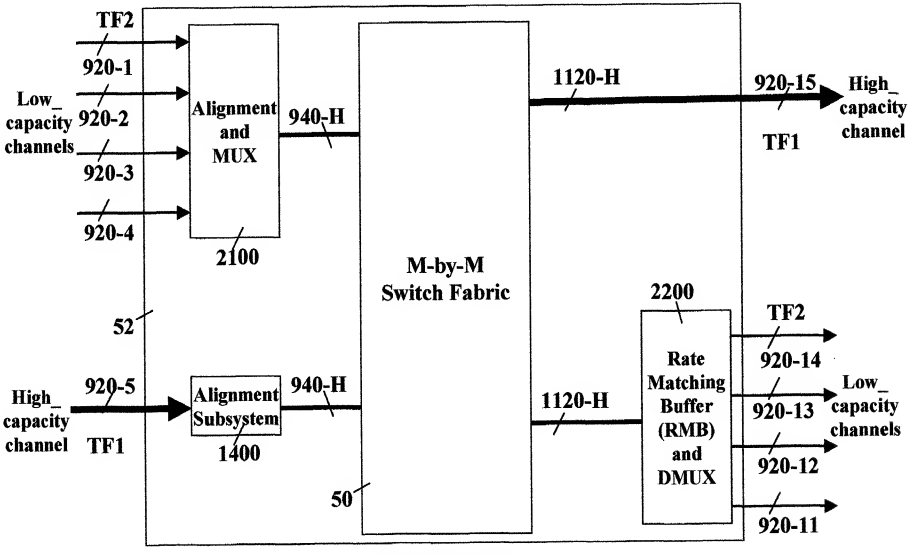
***S ((i,j),(k,l),t)* - switching matrix for every sub-time frame in each time cycle and super cycle.**

The matrix defines which input channel *i,j* should be connected to output channel *k,l* - in sub time frame *t*, where *S((i,j),(k,l),t)=1:*

1. **At every sub-time frame an input channel can be connected to one or more output optical channels (multicast - MCST)**
2. **At every sub-time frame an output optical channel can be connected to at most one input optical channel**

FIG. 22

N: number of input/output channels. E.g., N=256
M • High_capacity = N_high • High_capacity + N_low • Low_capacity
M<N



Time Driven Switch

FIG. 23

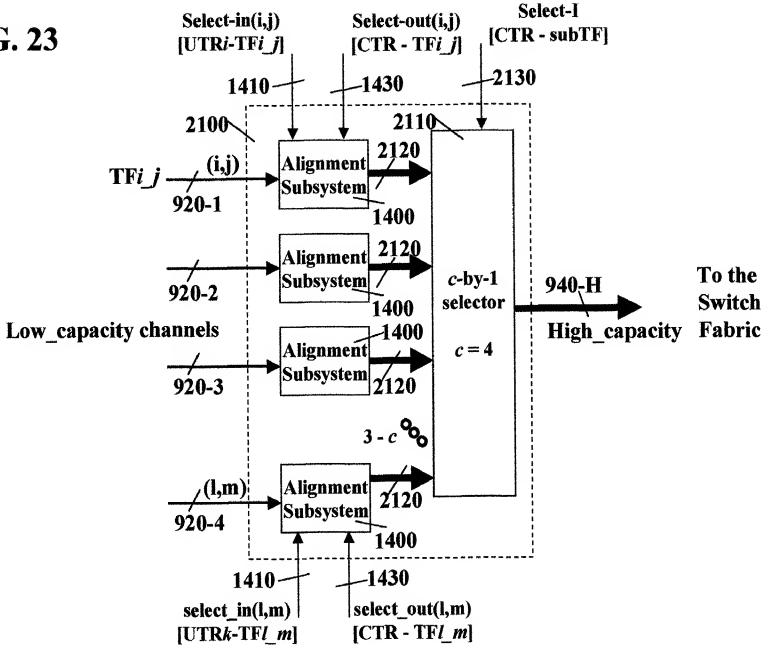


FIG. 24

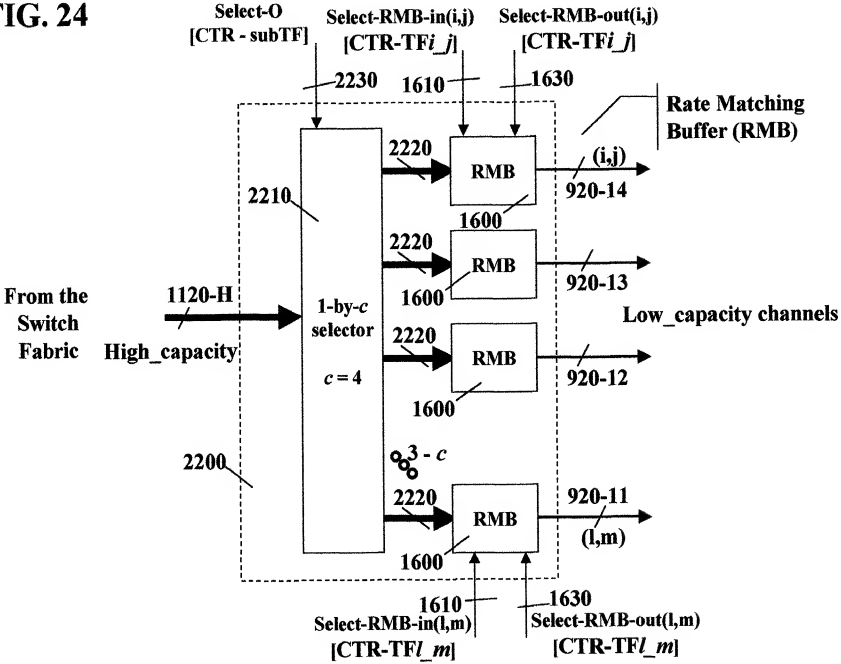


FIG. 25

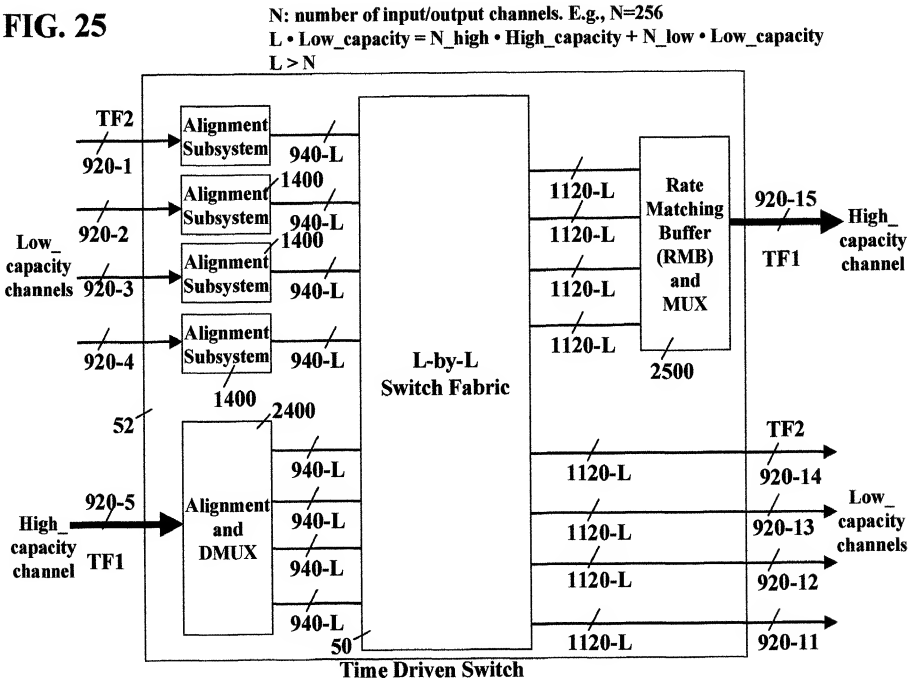


FIG. 26

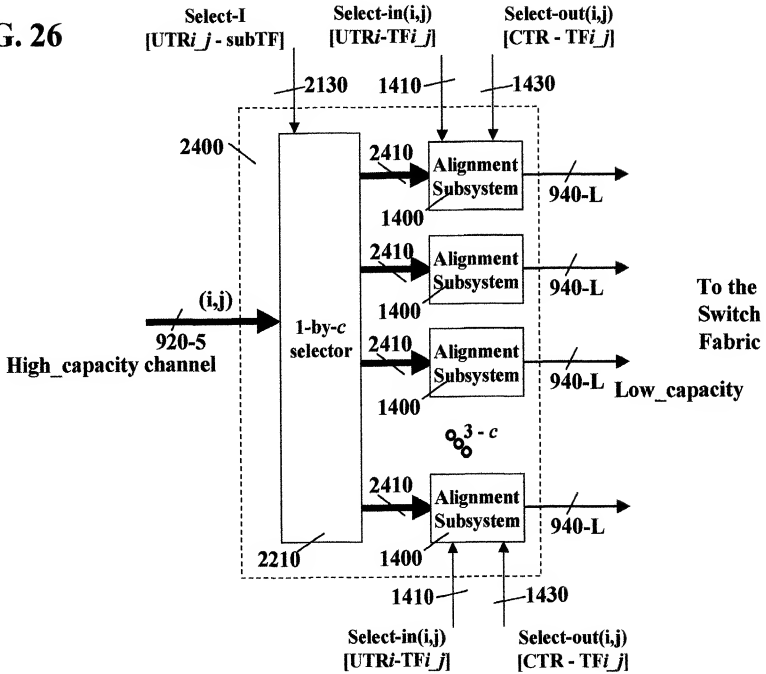


FIG. 27

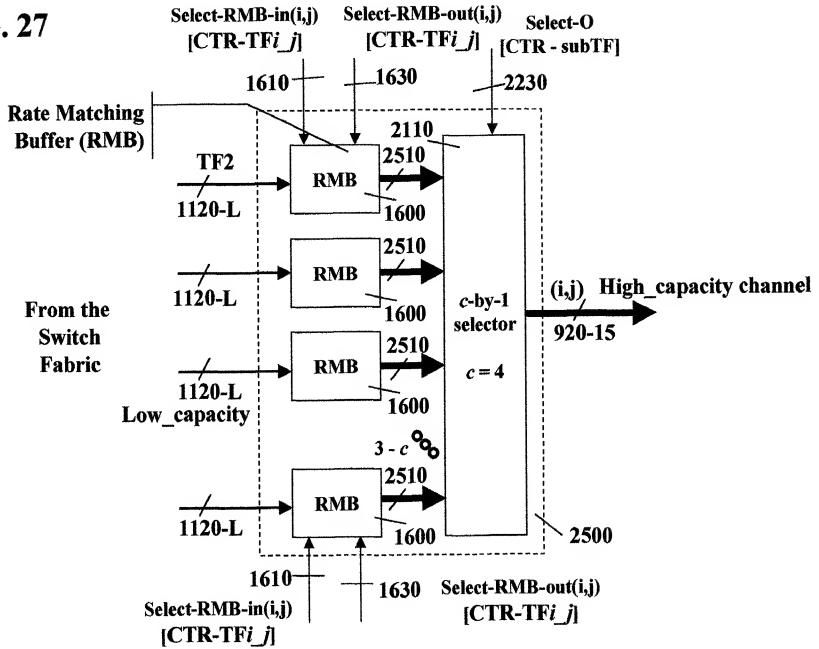
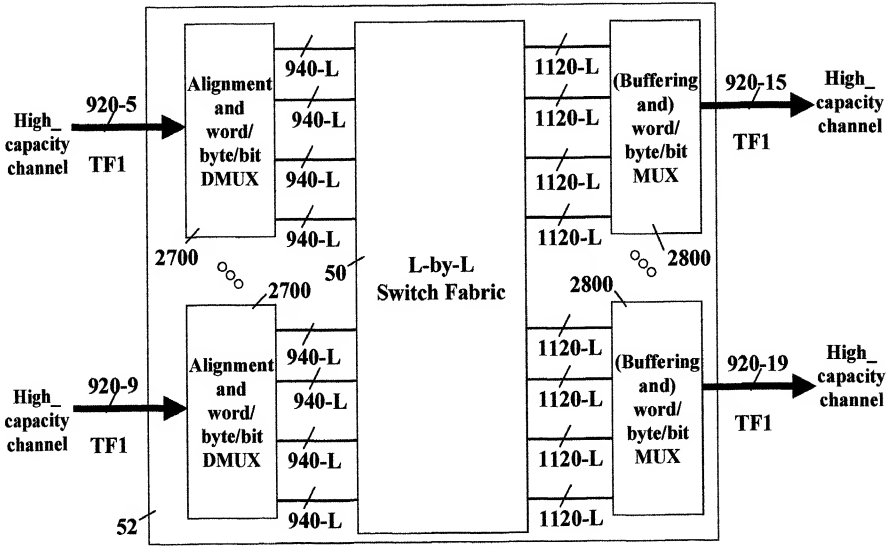


FIG. 28

N: number of input/output channels. E.g., N=256
L • Low_capacity = N • High_capacity
L = c • N > N



Time Driven Switch

FIG. 29

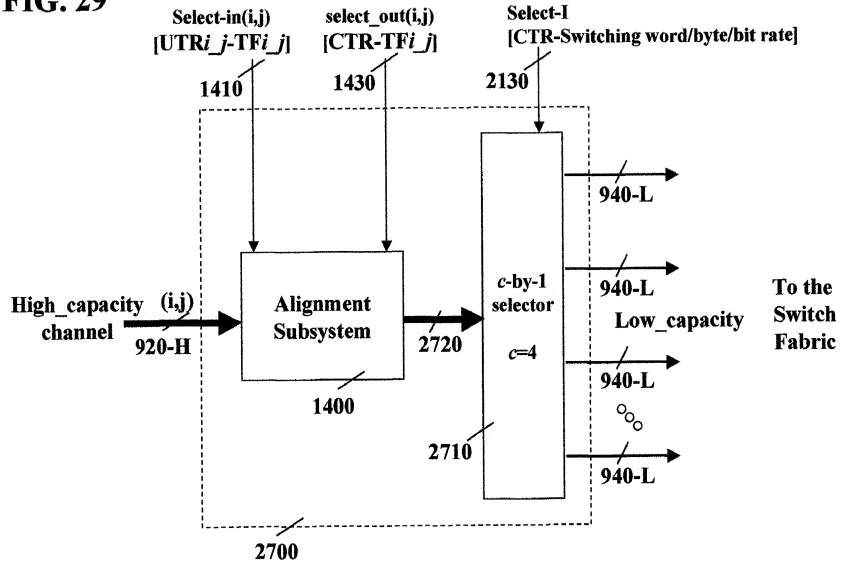


FIG. 30

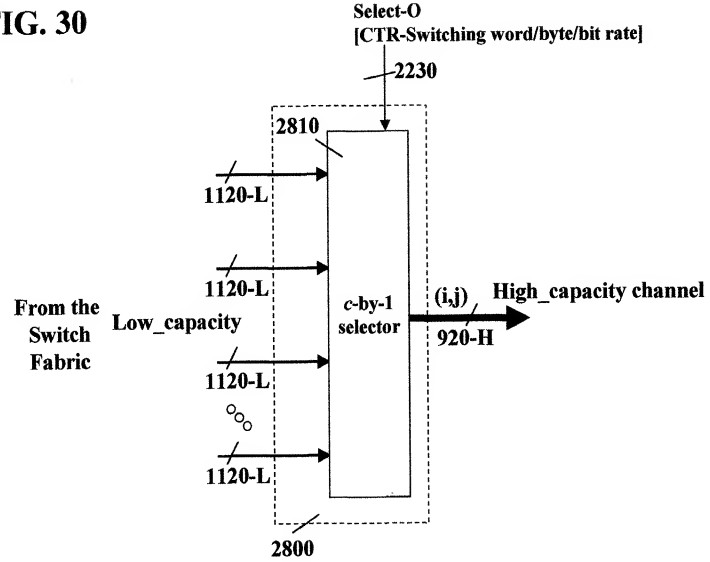


FIG. 31

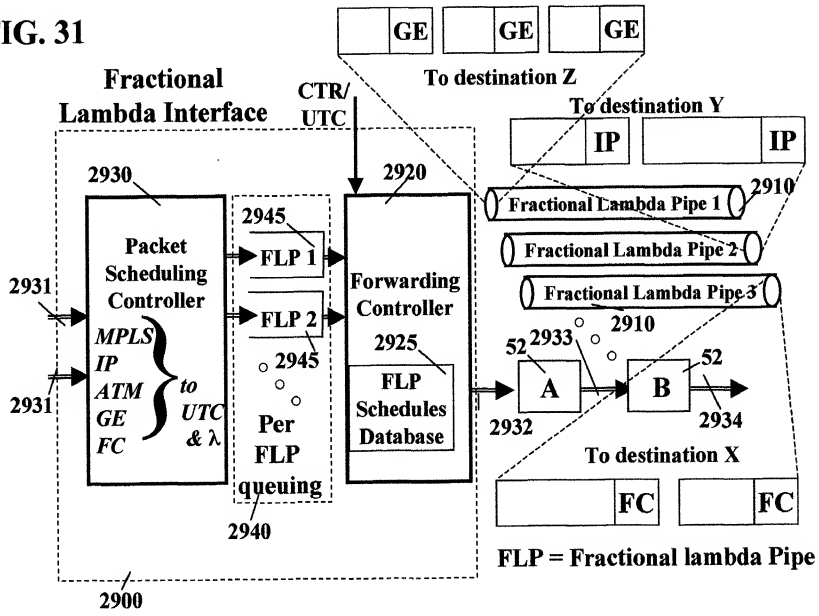


FIG. 32

Channel Capacity		TF Duration	TF Size		STS-1s	TFs/s
51.84	STS- 1	250	1620	1512	2	4000
		500	3240	3024	4	2000
		1000	6480	6048	8	1000
155.52	STS- 3	125	2430	2268	3	8000
		250	4860	4536	6	4000
		500	9720	9072	12	2000
622.08	STS- 12	62.5	4860	4536	6	16000
		125	9720	9072	12	8000
		250	19440	18144	24	4000
2488.32	STS- 48	62.5	19440	18144	24	16000
		31.25	9720	9072	12	32000
		15.625	4860	4536	6	64000
9953.28	STS- 192	7.8125	9720	9072	12	128000
		15.625	19440	18144	24	64000
1000	GE	125	15625	15625	19.3	8000
		100	12500	12500	15.4	10000
		80	10000	10000	12.3	12500
10000	10GE	15.625	19531.25	19531.3	24.1	64000
		12.5	15625	15625	19.3	80000
		10	12500	12500	15.4	100000

FIG. 33

Ch Capacity		*TF Dur.*	*TF Size*	*GE TFs*	*TFs/s*
1000	**GE**	**80**	**10000**	**1.0**	**12500**
51.84	STS- 1	250	1512	0.15	4000
		500	3024	0.30	2000
		1000	6048	0.60	1000
155.5	STS- 3	125	2268	0.23	8000
		250	4536	0.45	4000
		500	9072	0.91	2000
622.1	STS- 12	62.5	4536	0.45	16000
		125	9072	0.91	8000
		250	18144	1.81	4000
2488	STS- 48	62.5	18144	1.81	16000
		31.25	9072	0.91	32000
		15.625	4536	0.45	64000
9953	STS- 192	7.8125	9072	0.91	128000
		15.625	18144	1.81	64000
10000	10GE	8	10000	1.00	125000
		16	20000	2.00	62500

FIG. 34

Ch Capacity		TF Dur.	TF Size	GE TFs	TFs/s
1000	**GE**	**62.5**	**7812.5**	**1.0**	**16000**
51.84	STS- 1	250	1512	0.19	4000
		500	3024	0.39	2000
		1000	6048	0.77	1000
155.52	STS- 3	125	2268	0.29	8000
		250	4536	0.58	4000
		500	9072	1.16	2000
622.08	STS- 12	62.5	4536	0.58	16000
		125	9072	1.16	8000
		250	18144	2.32	4000
2488.32	STS- 48	62.5	18144	2.32	16000
		31.25	9072	1.16	32000
		15.625	4536	0.58	64000
9953.28	STS- 192	7.8125	9072	1.16	128000
		15.625	18144	2.32	64000
10000	10GE	12.5	15625	2.00	80000
		25	31250	4.00	40000

FIG. 35

***TF Alignment of* UTR(j) *to* UTC - with three input queues - principle of operation:**
The same queue is not used simultaneously for:
1. Receiving data packets from the serial link, and
2. Forwarding data packets to the switch

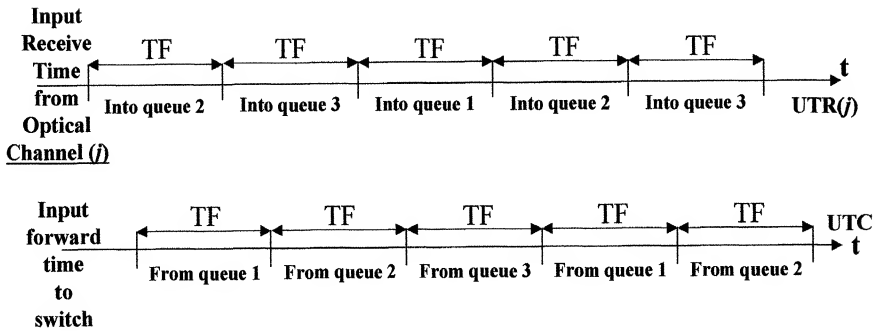


FIG. 36

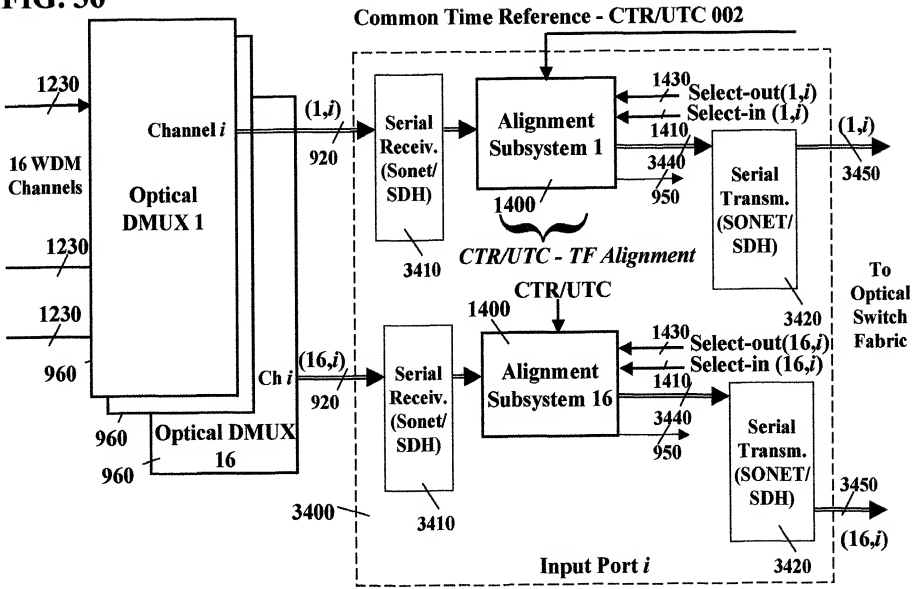


FIG. 37

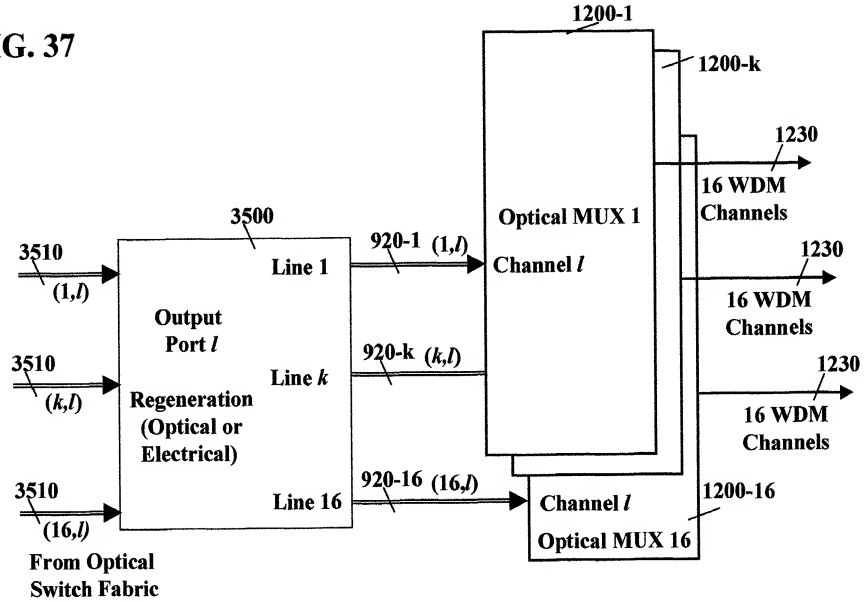
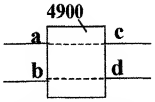
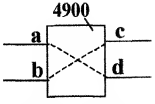


FIG. 38A



Straight Connection of a
2-by-2 Optical Switching Block

FIG. 38B



Cross Connection of a
2-by-2 Optical Switching Block

FIG. 38C

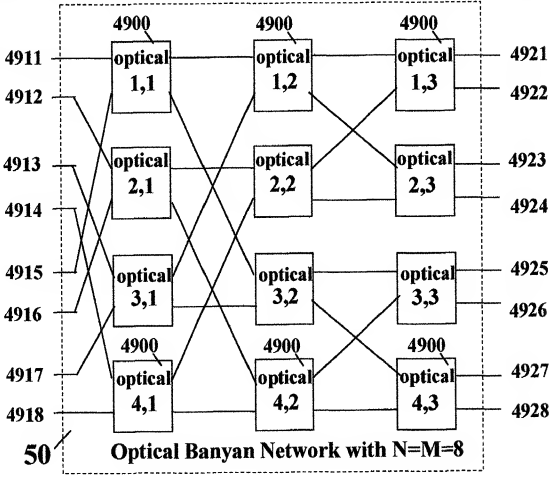
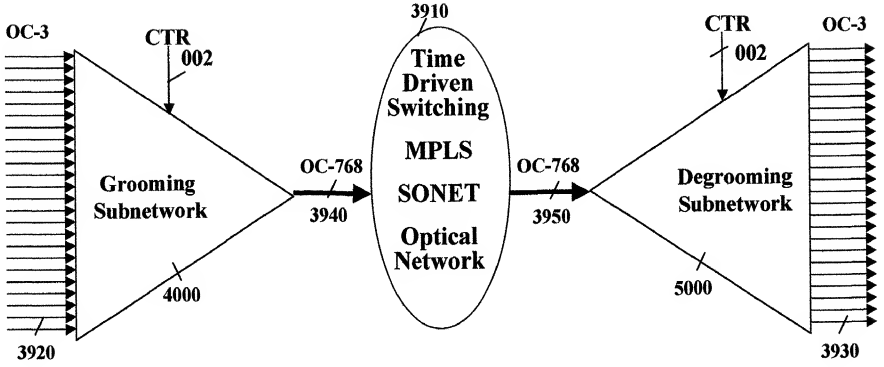


FIG. 39



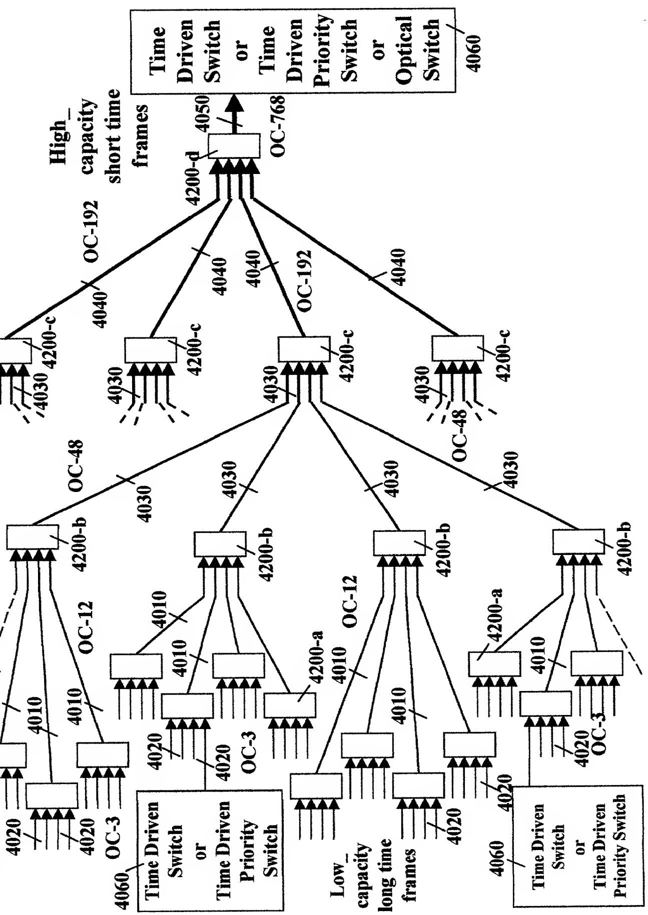

Time Driven Switch or Time Driven Priority Switch or Optical Switch
4060
High_ capacity short time frames
4050
OC-768
4200-d
OC-192
4040
4200-c
4030
OC-48
4200-b
4010
OC-12
4200-a
4020
OC-3
Time Driven Switch or Time Driven Priority Switch
4060
Low_ capacity long time frames
Time Driven Switch or Time Driven Priority Switch
4060

FIG. 40

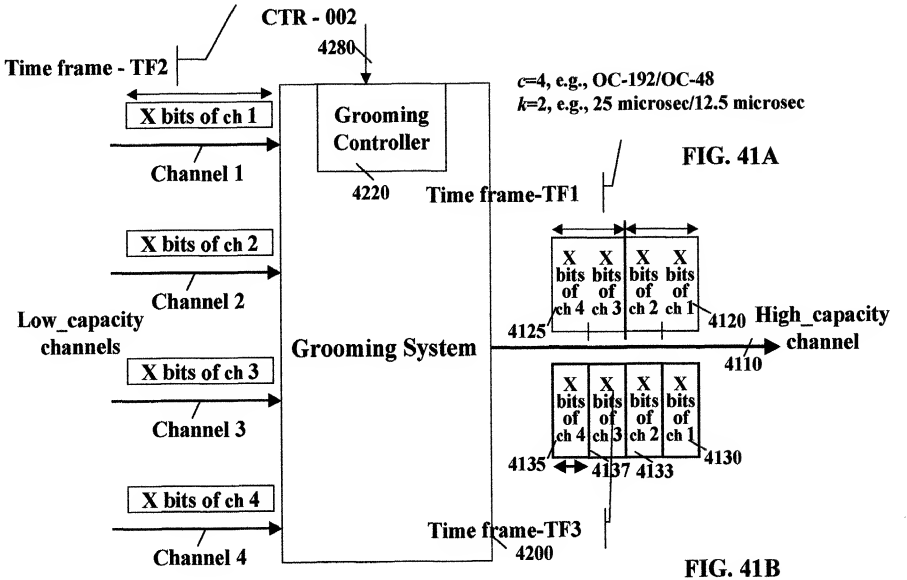


FIG. 42

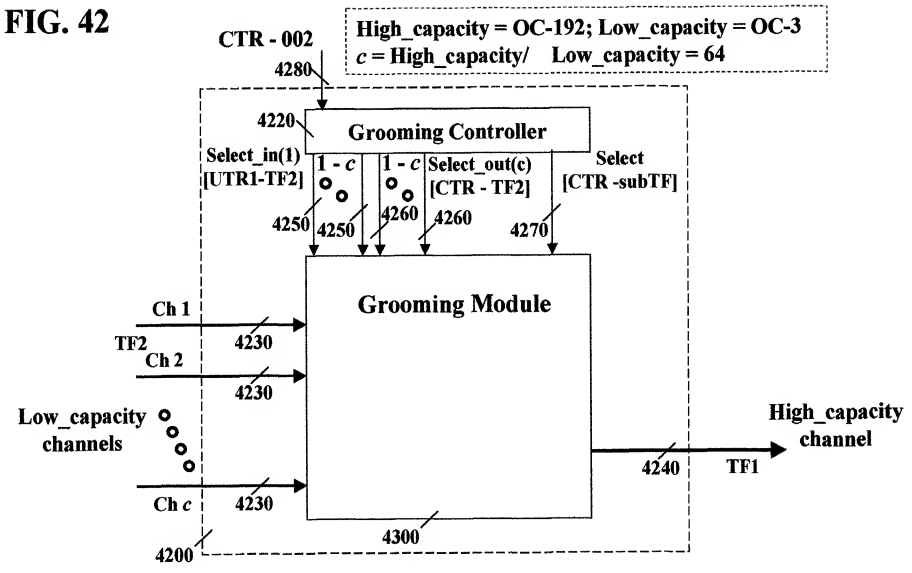

High_capacity = OC-192; Low_capacity = OC-3
c = High_capacity/ Low_capacity = 64
CTR - 002
4280
4220
Grooming Controller
Select_in(1)
[UTR1-TF2]
1 - c
1 - c
Select_out(c)
[CTR - TF2]
Select
[CTR -subTF]
4250
4250
4260
4260
4270
Grooming Module
Ch 1
TF2
4230
Ch 2
4230
Low_capacity
channels
Ch c
4230
High_capacity
channel
4240
TF1
4300
4200

FIG. 43

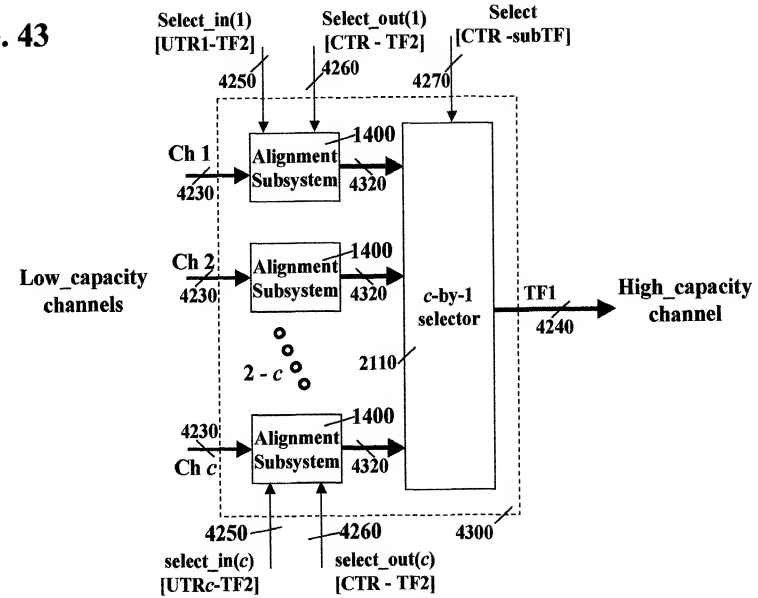


FIG. 44

- $CC1\_length \cdot TF1 = CC2\_length \cdot TF2 = CC3\_length \cdot TF2$
- $TF2 = (SC1\_length / SC2\_length) \cdot TF1 = k \cdot TF1$, where the common cycles of $TF1$ and $TF2$ are aligned with respect to UTC.

For $k = 2$ and $c = 4$ (e.g., High_capacity=OC-192, Low_capacity=OC-48):

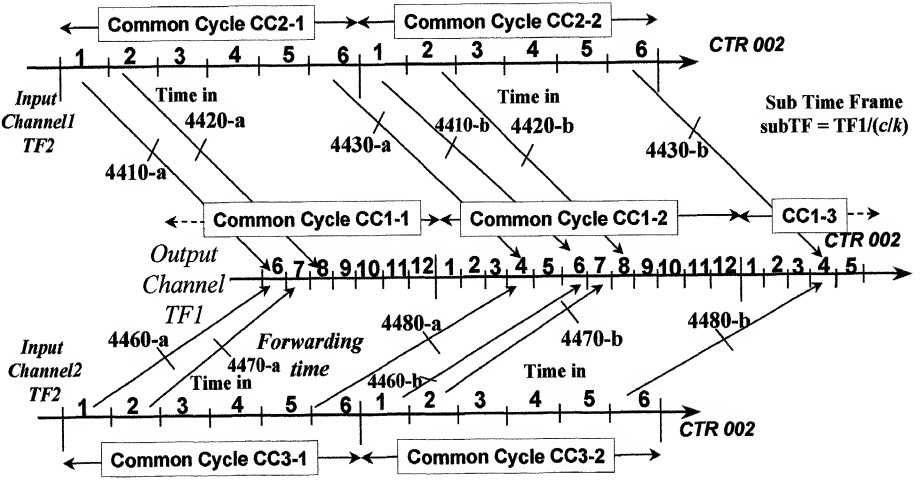
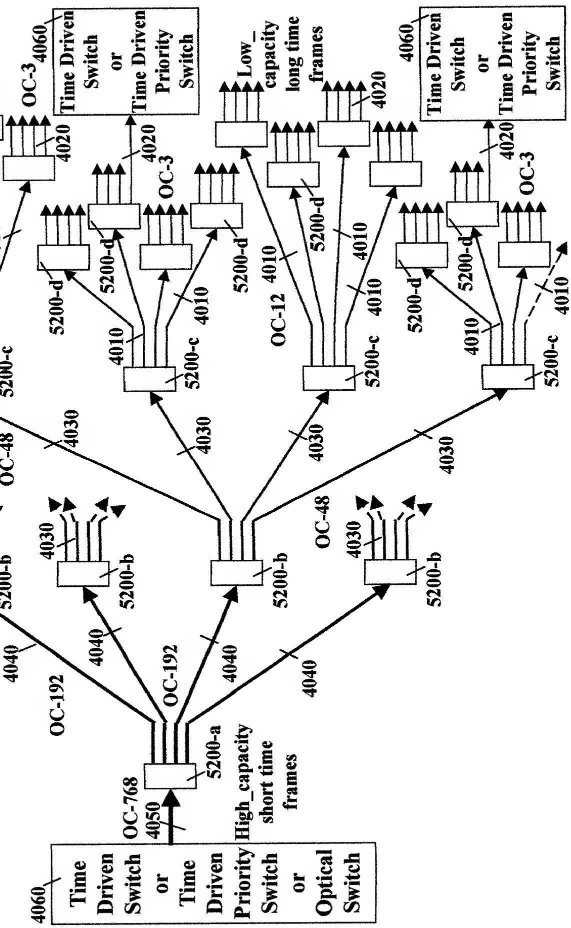


FIG. 45


4060
Time Driven Switch or Time Driven Priority Switch or Optical Switch
OC-768
4050
High_capacity short time frames
5200-a
OC-192
4040
5200-b
4030
OC-48
5200-c
OC-12
4010
5200-d
OC-3
4020
Low_capacity long time frames
Time Driven Switch or Time Driven Priority Switch

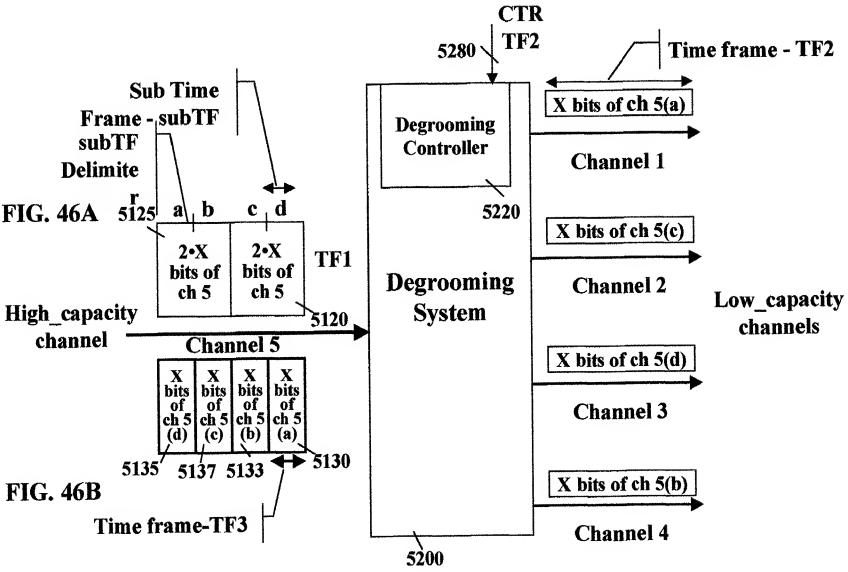


FIG. 46A

FIG. 46B

c=4, e.g., OC-192/OC-48
k=2, e.g., 25 microsec/12.5 microsec

FIG. 47

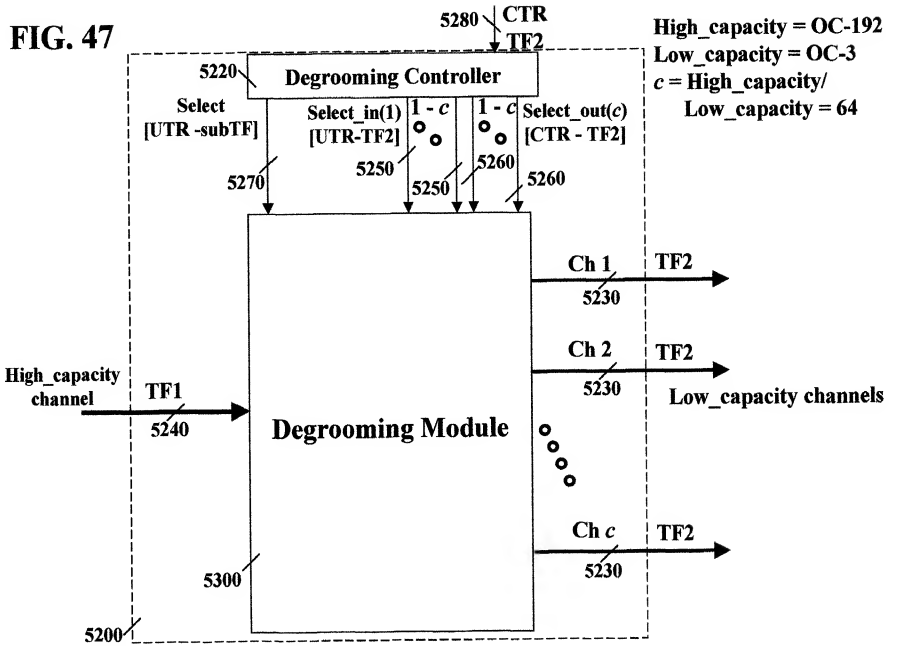


FIG. 48

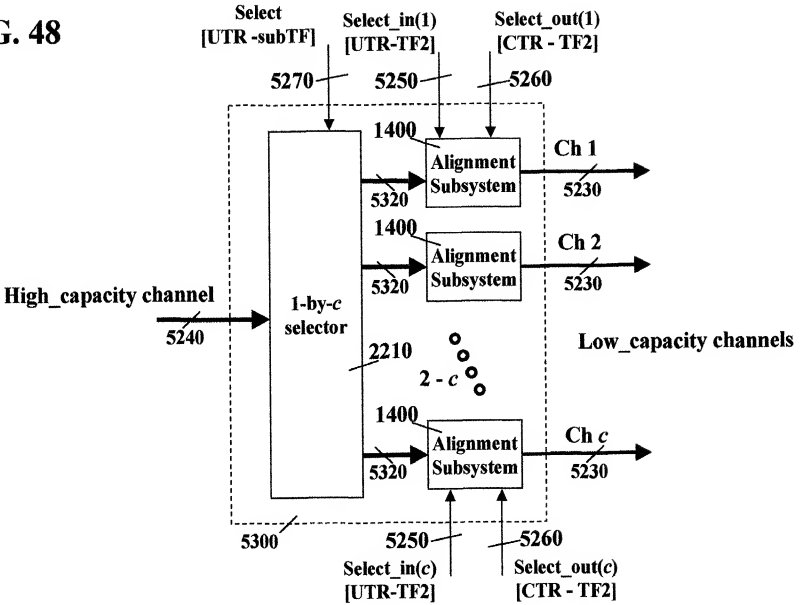


FIG. 49

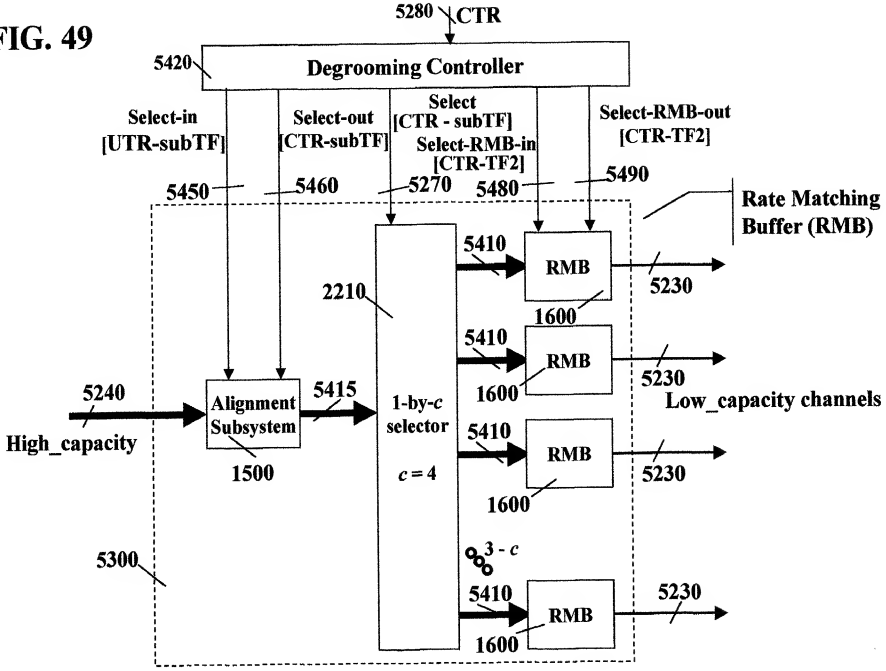


FIG. 50

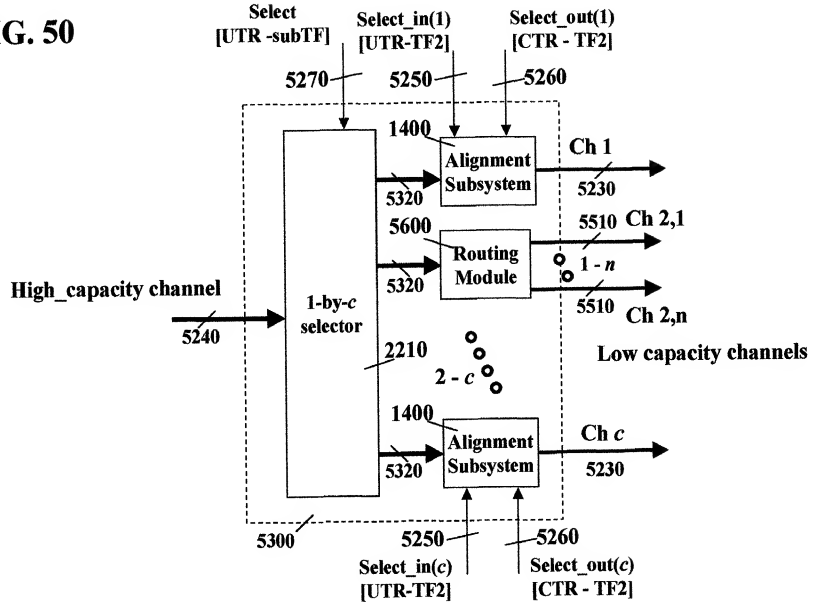


FIG. 51

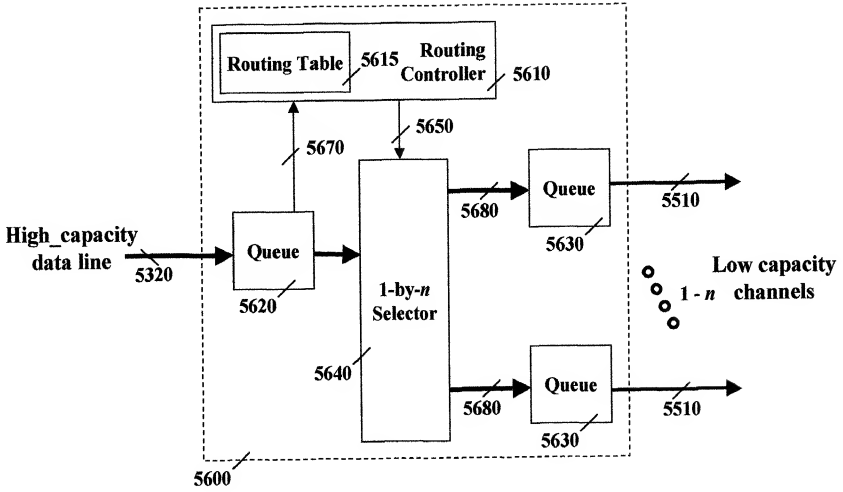


FIG. 52

- $CC1\_length \cdot TF1 = CC2\_length \cdot TF2 = CC3\_length \cdot TF2$
- $TF2 = (SC1\_length / SC2\_length) \cdot TF1 = k \cdot TF1$, where the common cycles of *TF1* and *TF2* are aligned with respect to UTC.

For $k = 2$ and $c = 4$ (e.g., High_capacity=OC-192, Low_capacity=OC-48):

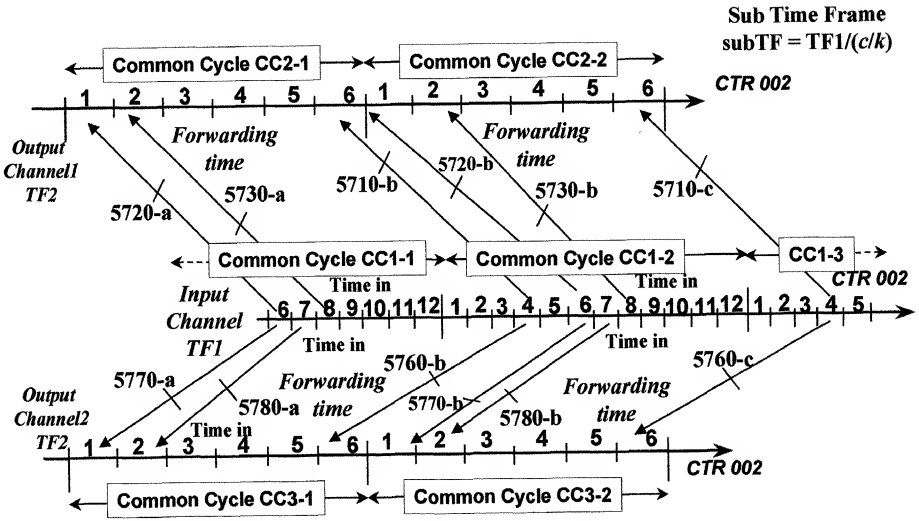


FIG. 53

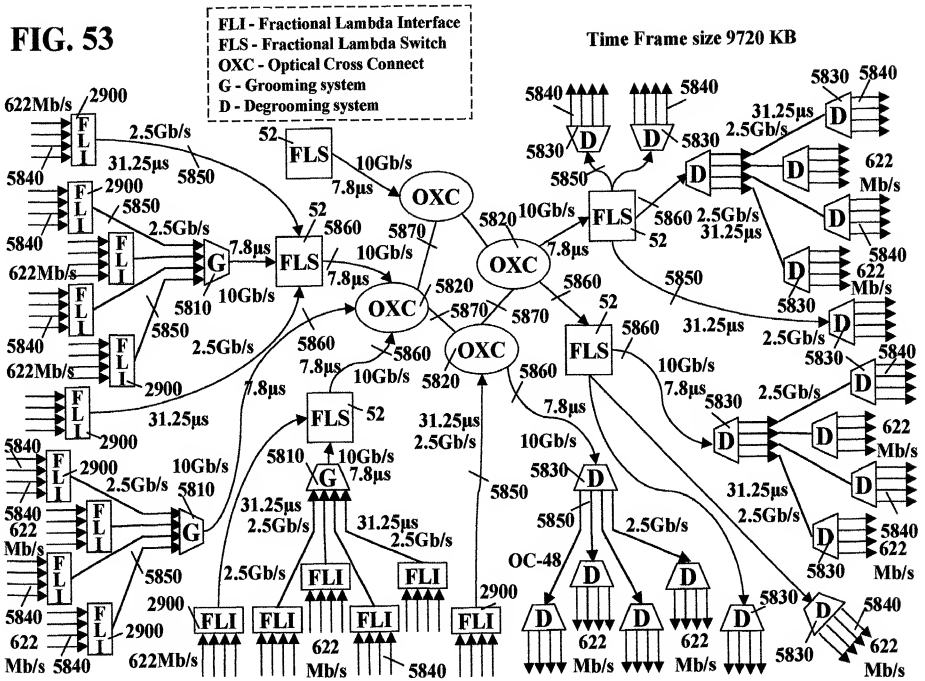


FIG. 54

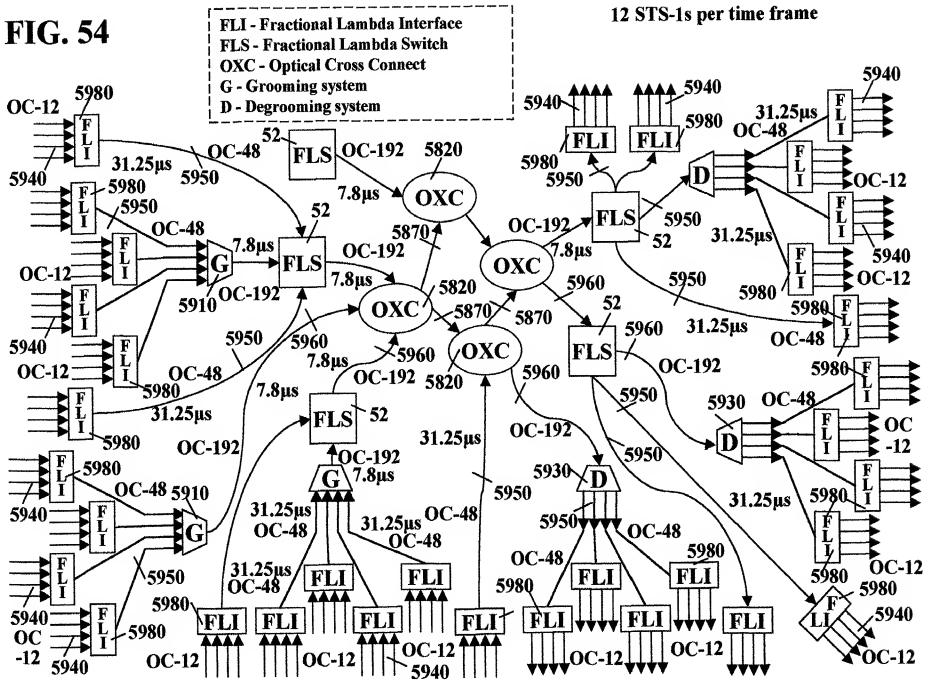
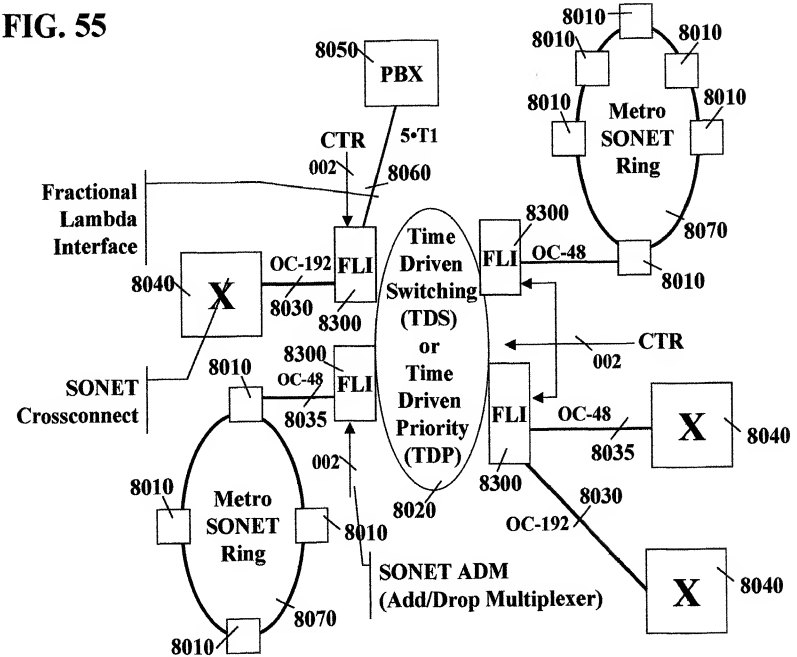
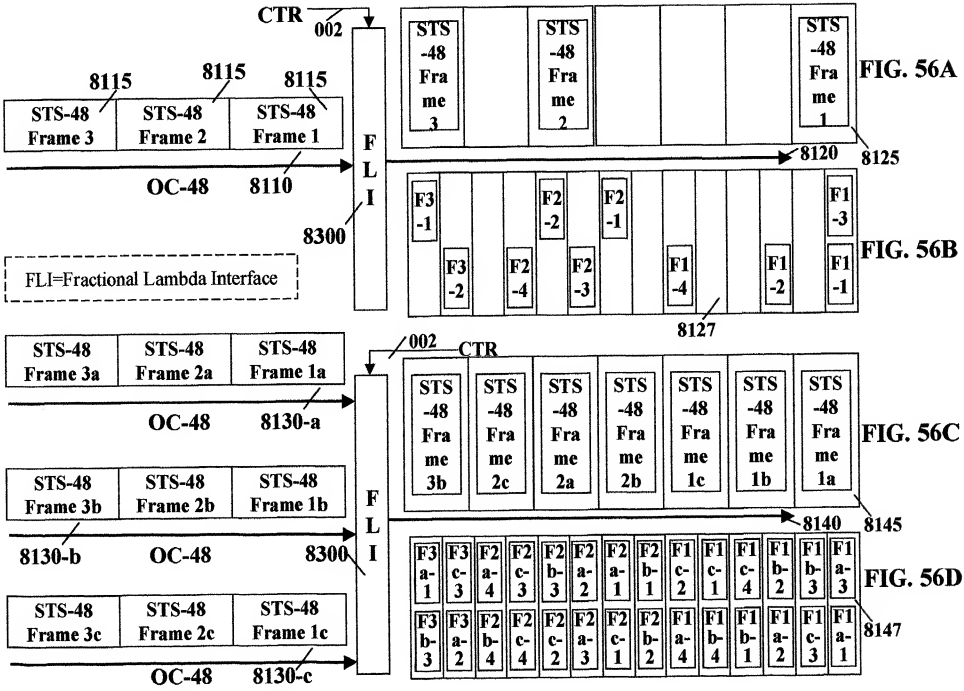
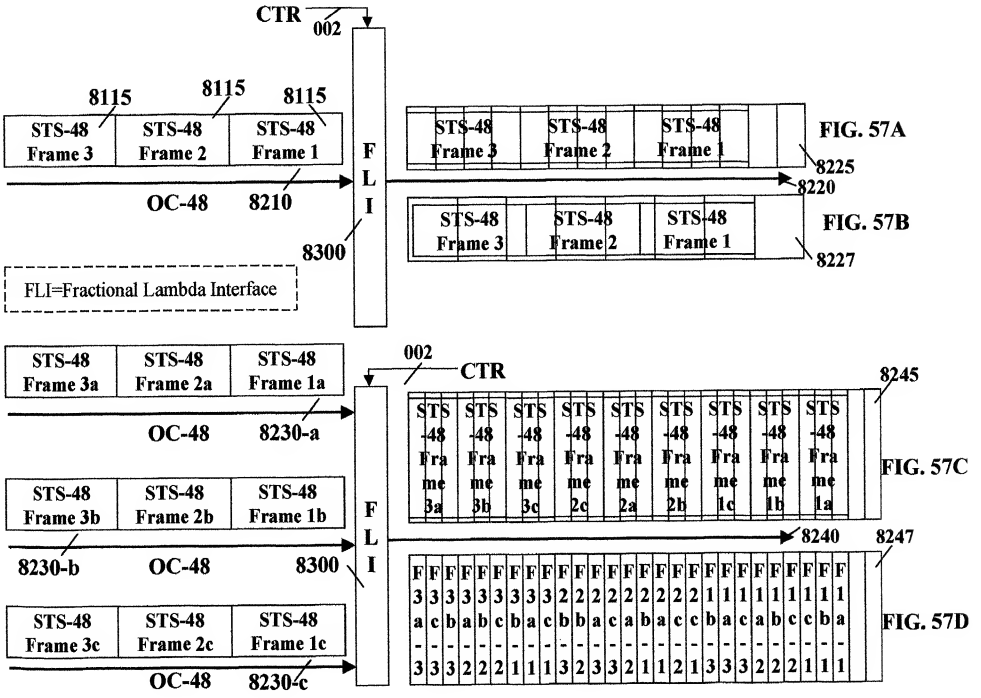

FLI - Fractional Lambda Interface
FLS - Fractional Lambda Switch
OXC - Optical Cross Connect
G - Grooming system
D - Degrooming system
12 STS-1s per time frame
OC-12
OC-48
OC-192
FLI
FLS
OXC
G
D
5980
5940
5950
5960
5910
5820
5870
5930
52
31.25µs
7.8µs
OC
-12

FIG. 55




CTR
002
8115
8115
8115
STS-48 Frame 3
STS-48 Frame 2
STS-48 Frame 1
OC-48
8110
FLI
8300
FLI=Fractional Lambda Interface
STS -48 Fra me 3
STS -48 Fra me 2
STS -48 Fra me 1
8120
8125
FIG. 56A
F3 -1
F3 -2
F2 -4
F2 -2
F2 -3
F2 -1
F1 -4
F1 -2
F1 -3
F1 -1
8127
FIG. 56B
STS-48 Frame 3a
STS-48 Frame 2a
STS-48 Frame 1a
OC-48
8130-a
002
CTR
STS -48 Fra me 3b
STS -48 Fra me 2c
STS -48 Fra me 2a
STS -48 Fra me 2b
STS -48 Fra me 1c
STS -48 Fra me 1b
STS -48 Fra me 1a
8140
8145
FIG. 56C
STS-48 Frame 3b
STS-48 Frame 2b
STS-48 Frame 1b
8130-b
OC-48
8300
F3 a-1
F3 c-3
F2 a-4
F2 c-3
F2 b-3
F2 a-2
F2 a-1
F2 b-1
F1 c-2
F1 c-1
F1 c-4
F1 b-2
F1 b-3
F1 a-3
F3 b-3
F3 a-2
F2 b-4
F2 c-4
F2 c-2
F2 a-3
F2 c-1
F2 b-2
F1 a-4
F1 b-4
F1 b-1
F1 a-2
F1 c-3
F1 a-1
8147
FIG. 56D
STS-48 Frame 3c
STS-48 Frame 2c
STS-48 Frame 1c
OC-48
8130-c


CTR
002
8115
8115
8115
STS-48 Frame 3
STS-48 Frame 2
STS-48 Frame 1
OC-48
8210
FLI
8300
FLI=Fractional Lambda Interface
STS-48 Frame 3
STS-48 Frame 2
STS-48 Frame 1
8225
8220
FIG. 57A
STS-48 Frame 3
STS-48 Frame 2
STS-48 Frame 1
8227
FIG. 57B
STS-48 Frame 3a
STS-48 Frame 2a
STS-48 Frame 1a
OC-48
8230-a
002
CTR
8245
FIG. 57C
STS-48 Frame 3b
STS-48 Frame 2b
STS-48 Frame 1b
8230-b
OC-48
8300
8240
8247
STS-48 Frame 3c
STS-48 Frame 2c
STS-48 Frame 1c
OC-48
8230-c
FIG. 57D

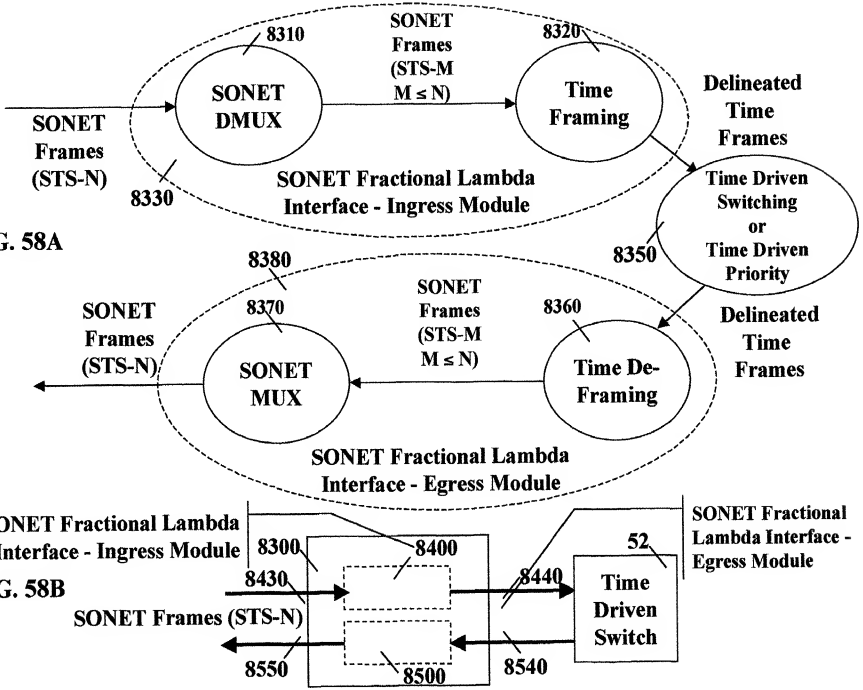


FIG. 58A

FIG. 58B

FIG. 59

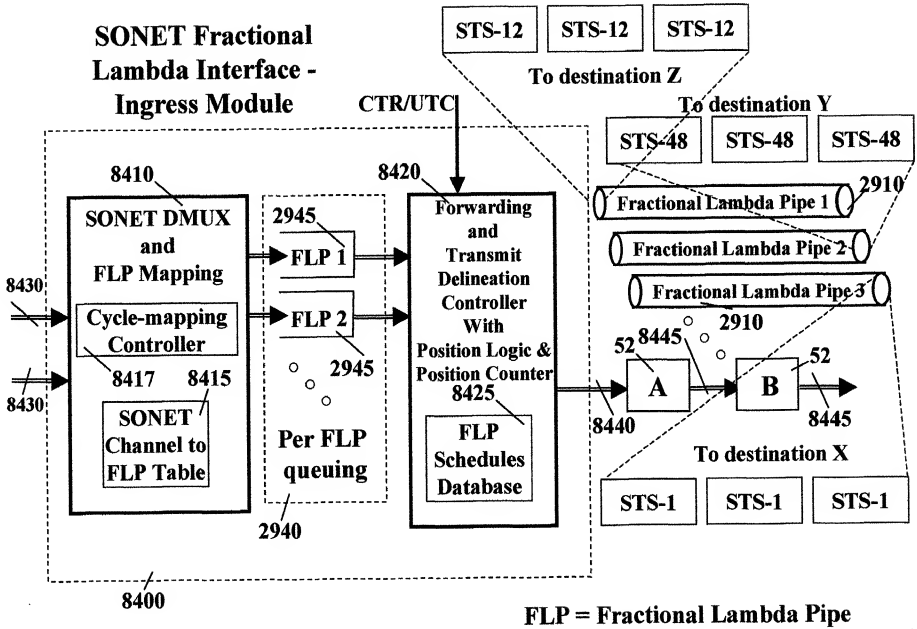
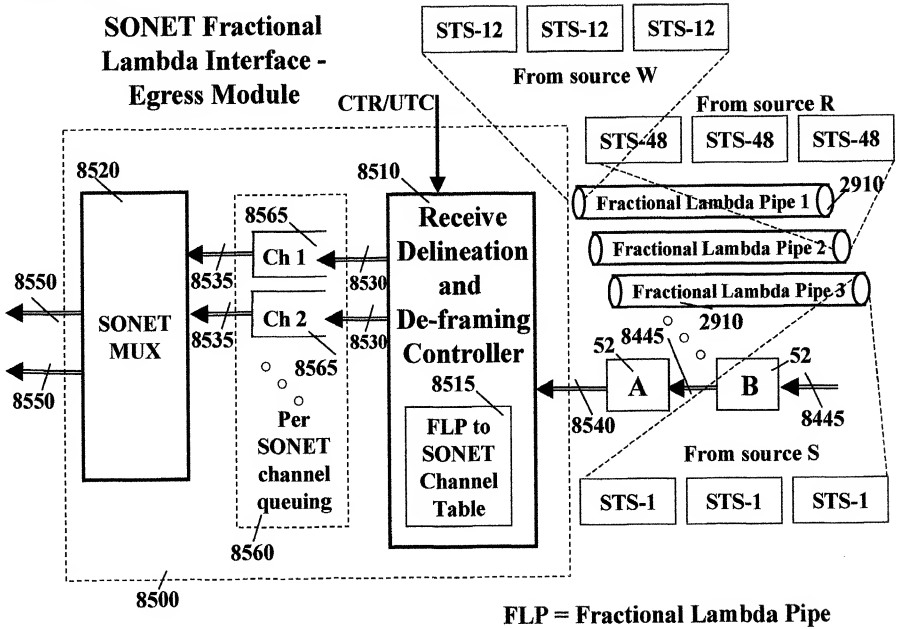


FIG. 60



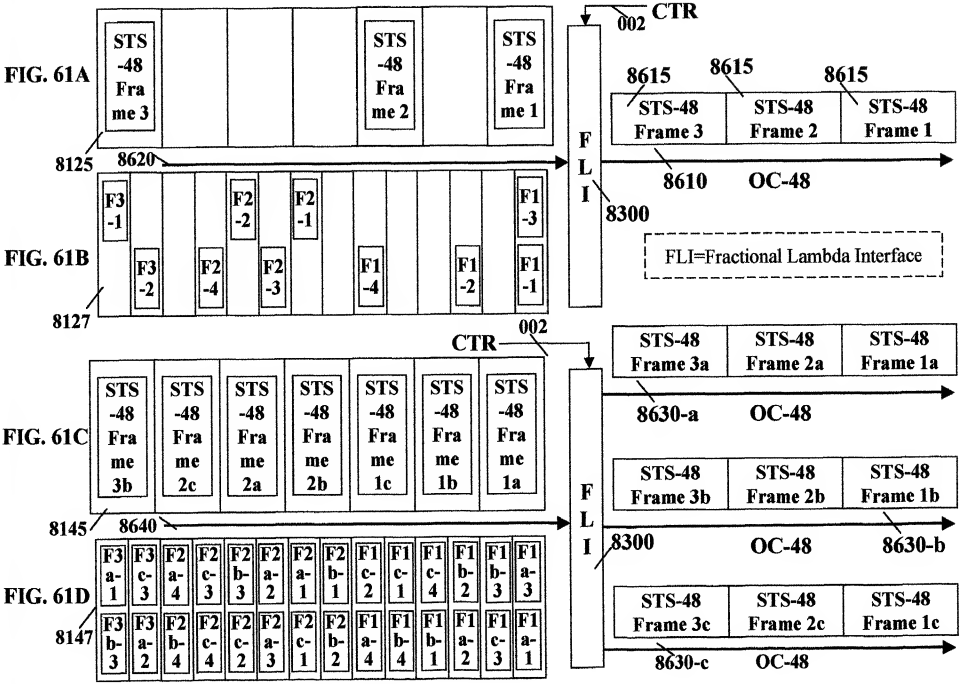
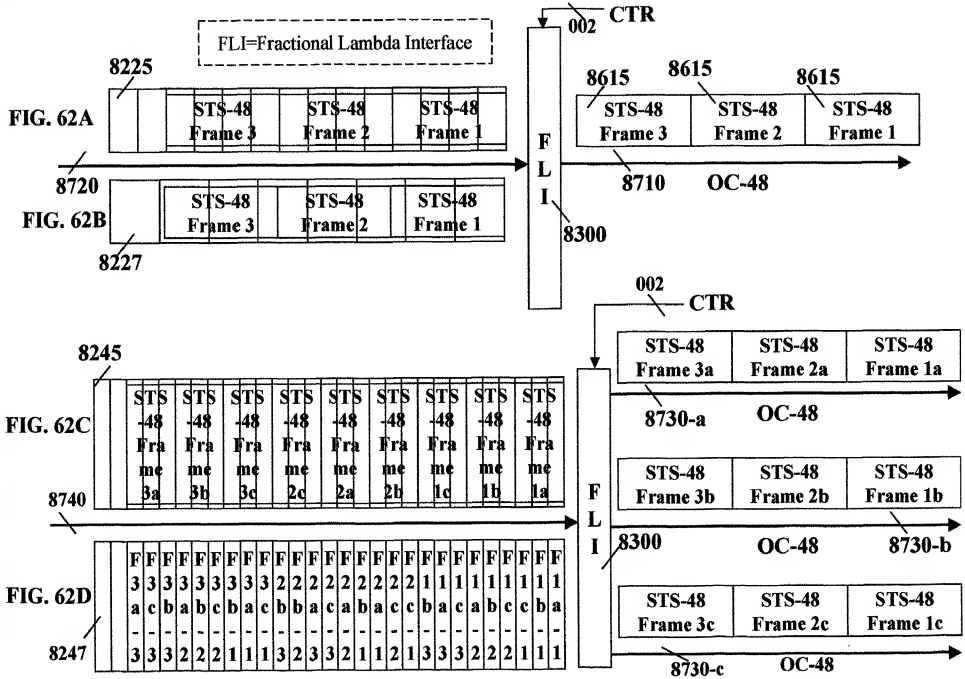


FIG. 61A
STS -48 Fra me 3
STS -48 Fra me 2
STS -48 Fra me 1
8125
8620
002
CTR
F L I
8615
8615
8615
STS-48 Frame 3
STS-48 Frame 2
STS-48 Frame 1
8610
OC-48
8300
FIG. 61B
F3 -1
F3 -2
F2 -4
F2 -2
F2 -3
F2 -1
F1 -4
F1 -2
F1 -3
F1 -1
8127
FLI=Fractional Lambda Interface
FIG. 61C
STS -48 Fra me 3b
STS -48 Fra me 2c
STS -48 Fra me 2a
STS -48 Fra me 2b
STS -48 Fra me 1c
STS -48 Fra me 1b
STS -48 Fra me 1a
8145
8640
STS-48 Frame 3a
STS-48 Frame 2a
STS-48 Frame 1a
8630-a
OC-48
STS-48 Frame 3b
STS-48 Frame 2b
STS-48 Frame 1b
8300
OC-48
8630-b
FIG. 61D
F3 a-1
F3 c-3
F2 a-4
F2 c-3
F2 b-3
F2 a-2
F2 a-1
F2 b-1
F1 c-2
F1 c-1
F1 c-4
F1 b-2
F1 b-3
F1 a-3
F3 b-3
F3 a-2
F2 b-4
F2 c-4
F2 c-2
F2 a-3
F2 c-1
F2 b-2
F1 a-4
F1 b-4
F1 b-1
F1 a-2
F1 c-3
F1 a-1
8147
STS-48 Frame 3c
STS-48 Frame 2c
STS-48 Frame 1c
8630-c
OC-48


FLI=Fractional Lambda Interface
8225
STS-48 Frame 3
STS-48 Frame 2
STS-48 Frame 1
FIG. 62A
8720
FIG. 62B
8227
002
CTR
F L I
8615
8615
8615
8710
OC-48
8300
8245
FIG. 62C
8740
FIG. 62D
8247
8730-a
8730-b
8730-c

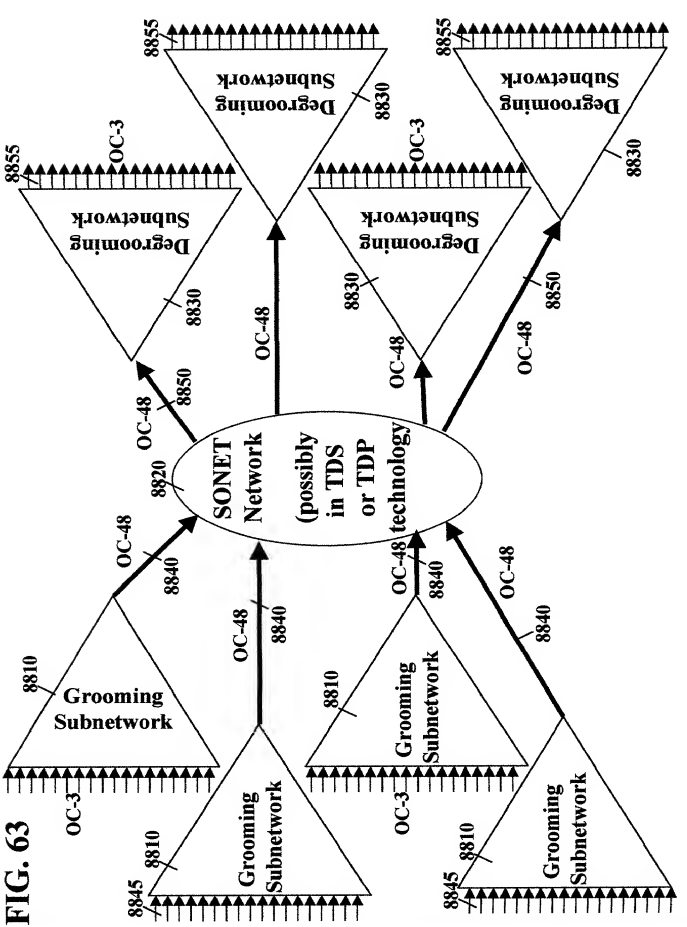


FIG. 63

- SONET - synchronous optical network
- Multiplexing method: byte interleaving
- Signal hierarchy: OC-N (STS-N)
  - STS-N rate: N*51.84 Mb/s
  - Frame format: 9 rows by 90*N columns
    - capacity: N*810 bytes in 125 microsecond.
    - overhead: N*27 bytes
    - payload: N*783 bytes

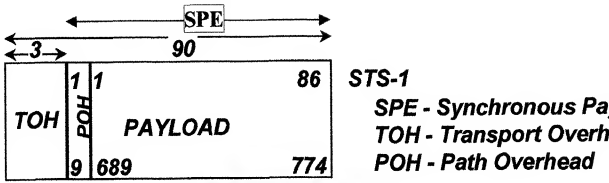


FIG. 64A

FIG. 64B

FIG. 65